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Forest Service

**Pacific
Northwest
Region**

A First Approximation of Ecosystem Health

National Forest System Lands

Pacific Northwest Region
June 1993

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United States Department of Agriculture **Forest Service** **RO**

Reply to: 1900 **Date:** September 24, 1993

Subject: Regional Ecological Assessment Report

To: Forest Supervisors and Directors

Enclosed for your information and use is the recently completed report, "A First Approximation of Ecosystem Health, National Forest System Lands, Pacific Northwest Region." This report is the first of its kind. It is the first time in the history of the Region we have a generalized snapshot of the overall health/condition of the National Forests from an ecosystem framework. I want to thank the subregional teams, and especially the Area Ecologists, for the excellent work that made this report possible.

I view this project as a significant step in the implementation of the Ecosystem Management Strategy (September 4, 1992). The purpose for doing the Assessment was to provide strategic information about the Region from a broad "ecosystem" point of view and to accelerate our understanding of ecosystem concepts and principles. I am satisfied that the experience in completing the Assessment, as well as the information contained in the report, has and will continue to meet our original intentions.

Information that was developed for this assessment was utilized by the Scientific Panel that prepared the Westside Forest Ecosystem Management Assessment. The information in this report will be useful for determining priorities for watershed restoration that has been identified in the President's Forest Ecosystem Management Plan. The report will also serve as another source of baseline ecosystem information for the yet to be developed ecosystem based management strategy for Eastern Oregon and Washington.

In addition, we have learned that future ecosystem projects must involve other Federal and State Agencies and that the collection of consistent interforest/interagency resource information is a high priority.

I encourage you to continue to utilize the concept of the subregional teams, because the need to integrate activities at various scales is an obvious ecosystem principle. I would also like for you to share the report with your key contacts, partners, and other interested parties.

for Jerry L. Mosemith

JOHN E. LOWE
Regional Forester

Enclosure

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Executive Summary

In December 1992, Regional Forester John Lowe chartered the Regional Ecosystem Assessment Project (REAP). As part of REAP, several teams of resource specialists contributed to an assessment of ecological conditions on national forest lands in Oregon and Washington. Regional Forester Lowe wanted a first approximation of ecological sustainability, particularly as the Forest Service adjusts to an ecosystem approach to management. The results are summarized in this publication. This report addresses only the sustainability of physical and biological elements; it does not address social or economic needs.

To conduct the assessment, the teams used a conceptual approach developed by the Northern Region of the Forest Service entitled Sustaining Ecological Systems (SES). This approach recognizes that ecosystems are made up of elements and processes, and that each of them functions within a range of natural variability. The main principle underlying this approach suggests that when an element or process is pushed outside this range, that element and those depending upon it may not be sustained naturally.

A group of specialists outlined the methods for the short-term project. They selected river basin scale for a majority of the assessment. They identified measures that were diagnostic of ecosystem sustainability and representative of current issues. For each measure, the historic range of natural variability was compared to the current condition. Existing inventory data and professional judgement were the primary sources of background information specified for the assessment. Historic conditions were further recreated from old photos, journals, and maps.

Subregional results were summarized by a regional team. The coverage across the Pacific Northwest Region is incomplete. The eastern Oregon forests of Wallowa-Whitman, Umatilla, Malheur and Ochoco had finished an earlier ecological assessment (Caraher and others, July 1992, along with Ochoco Amendment, October 1992). The results from the earlier assessments are consistent with newer findings and have been incorporated into this report. Eastern Washington forests (Wenatchee, Okanogan and Colville) determined to wait until the Eastside Forest Ecosystem Health Assessment (Everett and others, April 1993) was complete. All other forests participated fully.

"Coarse filter" or broad scale analysis is a new process for many Forest Service specialists. Subregional teams experienced discomfort in estimating historic and current conditions at broad, river basin scales. Many assumptions and limitations are inherent in the assessment. However, the apparent patterns and trends are valuable to land managers.

The results of the assessment indicate that many ecological elements appear within sustainable ranges. We must recognize the ecosystems that appear functional and sustainable, and gain a better understanding of the management practices that may have contributed to the positive conditions.

The results also display ecological elements outside the natural range of variability. The following list describes those areas where ecosystems appear to depart from sustainable conditions:

- ❒ Loss of vegetative structure, in particular large trees, has led to a simplification of some ecosystems. As an example, many streams now exhibit fewer pools for fish habitat. One of the reasons most often associated with a reduction of pools is loss of in-channel structure such as large wood.

- ❒ There is a general increase in intermediate tributary stream temperatures from the past. Increased temperatures are typically associated with loss of riparian shade or channel widening. This condition appears most pronounced in eastern Oregon river basins.

- ❒ Though forests display a similar amount of early successional stage vegetation as the past, those containing snags and downed logs are significantly less.

- ❒ Though western Oregon and western Washington late successional single layer forests appear within the range of natural variability or above, late successional multilayered forests are generally at the low end of the range or below.

- ❒ Eastern Oregon late successional stage multilayered forests are within the range or above historic levels. Late successional single layer forests are substantially less than in the past in eastern Oregon.

- ❒ Patterns of openings and homogenous stands have been altered in the landscape from past disturbance processes. There is a higher density of small sized openings, and patches of mature forest are becoming increasingly more isolated.

- ❒ Smoke emissions from fire are less now than in the past, significantly so in the fire-adapted ecosystems of the eastside.

Future Recommendations

This assessment highlights future work recommendations to help progress toward new goals. All recommendations assume interagency participation, because ecosystems in the Pacific Northwest encompass many ownerships. Having readily available, quantitative information gathered and summarized in a consistent interagency manner is of high importance to future needs and goals.

Recommendations include research on historic and current disturbance processes, particularly the role of fire. Research is also recommended on the identification and use of key indicator elements of ecosystem health.

Those involved in the assessment project recommend that we fully implement the concept of desired range of acceptable conditions. In this capacity we would design our information and monitoring systems around key ecological indicator elements that will display our progress towards or away from desired range of acceptable conditions.

Introduction

On September 4, 1992, the Pacific Northwest Regional Forester and Station Director approved an **Ecosystem Management Strategy** for the Pacific Northwest Region and Research Station. That decision put several strategic programs and projects into motion including this regional ecological assessment.

An ecological assessment has been completed on National Forest System river basins in Oregon and Washington. Several ecosystem elements were evaluated to determine the overall condition of the landscape. The goal of the project was to provide strategic information about the Region from a broad "ecosystem" point of view. The assessment was designed to gain a "first approximation" or "coarse filter" analysis of ecological sustainability of northwest National Forests.

Completion of the assessment has provided us a generalized picture of the overall health/condition of the National Forests from an ecosystem framework, and has accelerated the Forest Service understanding of the concepts, principles, and procedures of ecosystem management. In addition, we have learned that future ecosystem projects must involve other Federal and State agencies and that development of interforest/interagency resource information must become a high priority.

The experience gained from completing the assessment and the information contained in this report will be useful for:

- incorporating ecosystem principles into project planning to design for positive cumulative effects,

- making efficient and consistent "Analysis of Management Situation" in Forest Plan adjustments,
- providing context for other kinds of analyses,
- identifying information gaps, and
- determining priorities for watershed restoration work.

The conceptual framework for the Assessment is the Sustaining Ecological Systems (SES) approach developed by the Northern Region of the Forest Service. SES is based upon the assumption that ecosystems vary over time and space. This dynamic nature of ecosystems underscores the need to consider ranges of conditions rather than snapshots in time. A key concept of the Northern Region approach suggests that when systems are "pushed" outside the bounds of a natural range of variability there is a substantial risk that biological diversity and ecological function may not be maintained. This approach suggests that an objective for most wildland environments is to manage such that ecological components are within a range of natural variability.

The range of natural variability changes as the time period during which it is defined changes. Many different conditions can be natural. In this document the range was defined as approximately from 1600 to the mid-1900's and will be referred to as "historic condition." The primary goal in estimating the range of natural variability was to consider pre-European settlement conditions.

The SES approach recognizes several scales to assess. Scales are hierarchical or arranged with smaller ecosystems nested inside larger ones. River basin scale was selected for this project. River basins are large geographic areas, often several hundred thousand acres, normally containing more than one watershed. Landscape patterns and conditions are more identifiable at river basin or coarse filter scale. Localized, finer filter assessment scales are more desirable during project planning and implementation.

Thousands of elements and processes affect the ecosystems of the Pacific Northwest. The complexity of these systems is immense. A group of specialists compiled a list of measures that reflect (directly or indirectly) key ecological elements and processes of aquatic, riparian, terrestrial and atmospheric ecosystems. These measures were then used by subregional teams to assess ecosystem health in local river basins. The measures were designed to diagnose ecological sustainability and to take advantage of existing Forest Service inventories and databases. Where data was unavailable, specialists used best professional judgement to supplement data gaps.

In this publication we display a summary of the results reported by the subregions. Graphic tables with companion narratives are offered to illustrate and describe more than eighty river basins in the Pacific Northwest Region. The tables compare current conditions with ranges of natural variability. The ranges of natural variability were derived from historic documents, maps, photos, and diaries in conjunction with regressive reconstructions from current resource inventories and ecology inventories.

Although the Forest Service is adjusting toward an ecological approach with incomplete knowledge, management experience and science have given us considerable information. Forests are a natural template that represent thousands of years of adaptation. The regional ecological assessment takes a first step in synthesizing what we know at a broad scale to provide a general picture of the biological and physical sustainability of Pacific Northwest ecosystems.

Methods

Study Area

The Pacific Northwest Region was divided into seven subregions of similar ecology. Within each area, subregional teams collected and analyzed ecological data. The subregions were further divided into major river basins (hydrologic units) as defined by the US Geological Survey (Figures 3 and 4).

Analysis

Data were assembled for aquatic, riparian, terrestrial, and atmospheric ecosystems. The subregional teams used data that had been previously collected because of the short time frame in which the analysis was to be completed. Teams were to establish a range of natural variability for each element listed below. Historic conditions were defined for the period between 1600 and 1850. Some teams were not able to identify data from that period and extended the analysis to include data up to the early 1900's.

Current conditions were estimated using several methods. When possible, particularly for the aquatic measurements, when several data points were available, the mode was shown. The terrestrial measures are expressed in percent of acres and are generally a direct estimate of the amount of a particular successional stage. These current conditions are not true modes, although they may be labeled as such.

Three measures were used to evaluate the health of aquatic ecosystems in each river basin. Aquatic areas are defined as the portion of national forest lands covered by surface water, primarily perennial streams. Inventories from intermediate tributaries were the primary source for current stream information. The measures are:

- **Percent of river basin disturbed** (early successional condition and impermeable to water infiltration). This measure contains key indicators of the potential for alteration of streamflow quantity, quality, and timing as a result of upland conversion.
- **Pool frequency** (per wetted channel width). This measure is included as a primary indicator of aquatic ecosystem condition, and a key habitat feature for anadromous and resident fisheries.
- **Maximum stream temperature**. This measure is also provided as a primary indicator of aquatic ecosystem condition; minor variations in stream temperature can have dramatic affects upon fish and invertebrate species.

Riparian areas are defined as the zone adjacent to water bodies which influence the physical or chemical character of the aquatic ecosystem. Two measures were used for riparian systems:

- **Percent of stream influence zone in early successional stage.** This measure is included to provide information about the integrity and condition of riparian areas.
- **Percent of bare ground within stream influence area** (eastside river basins only). Bare ground is defined as an area where groundcover that could prevent surface erosion does not exist. This measure is designed to show the influence of domestic and natural grazing upon riparian areas.

Two main measures were evaluated for terrestrial ecosystems:

- **Landscape Composition**
  - Percent of acres in early successional stage with historical levels of snags present
  - Percent of acres in early successional stage without snags present
  - Percent of acres in single layered canopy late successional stage

- Percent of acres in multilayered canopy late successional stage
- Percent of acres in dense, low-vigor stands (eastside river basins)

❍ **Landscape Pattern**

This was analyzed by qualitative estimates of the size, density, and juxtaposition of openings in the mature forest. Several landscapes were selected for quantitative analysis (Diaz, Kertis and Peter [1]). Analyses were completed using spatial statistics from the software package FRAGSTATS (McGarigal and Marks [2]).

In addition, two other measures were recognized as important to ecosystems, but that operated at a scale larger than the subregion; atmospheric emissions and genetic variability. Genetic assessments are more applicable in a fine filter approach and some examples are presented in Appendix B.

❍ **Atmospheric emissions** were analyzed at a Regional scale. The intent was to compare historic levels of PM10 (particulate matter of 10 microns or less) emissions from fire, to current PM10 emissions from prescribed fire and wildfire on national forest lands.

Blue Mountains Assessment

The Blue Mountain forests (Wallowa-Whitman, Umatilla and Malheur), in conjunction with the Ochoco National Forest team, considered different ecological elements in their assessments. They evaluated **riparian shrub cover** as an indicator of stream shading, bank stability, source of woody debris, and nutrient cycling through leaf-fall. They also looked directly at **streambank stability**. They evaluated **early successional, late successional park-like**, and **late successional tolerant multistory** elements within the Douglas-fir and true fir climax stands combined. Ponderosa pine stands and lodgepole pine stands with **high density and low vigor**, amounts of **available fuels**, and amounts of **juniper-grassland** were also evaluated.

Limitations

This assessment focused only on lands administered by the Forest Service. An ecological assessment should include all ownerships, particularly for aquatic components. In the interest of time to complete this project, we decided only to assess national forest lands for this first approximation.

Evaluation of a "range of natural variability" is difficult; it is a changing condition and may not always be the most appropriate measure of ecological integrity. Variability of the landscape over space and time is extreme. Any comparison to natural conditions will, at best, represent a comparison to another point in time. Future assessments should identify trends, processes and rates of change, in addition to variability in structures.

Differences in data, analysis methods, and historic records between national forests makes comparison of results sometimes difficult and occasionally inappropriate. Data collection and analysis ranged from site-specific computer based information systems to best professional judgement with very little supporting data. There was a lack of consistency in methods between national forests.

It was apparent in the aquatic section of the assessment there was general inconsistency in availability and quality of data. Although there has been significant progress in developing quantitative information to characterize aquatic and riparian habitat through the region-wide stream inventory program, it is apparent that much remains to be done. This assessment highlights the importance of having readily available, quatitative information which has been gathered and summarized in a consistent fashion. As issues such as anadromous fisheries expand and include multiple national forests, informed and coordinated management requires integrated information. The graphics in Figures 20-26 reflect data quality by river basin.

Estimation of historic and current conditions at river basin scale proved challenging for most subregional teams. The scale is much larger than scales used in the past. This coarse filter scale is beneficial for broad scale, cumulative effects analysis, but potentially misleading when looking at specific locations within the larger framework. All specialists who participated recognized this scale is necessary for an ecological approach to management.

Figures 5 to 34 summarize assessment results. In several cases data is missing because the measure did not pertain to that river basin or there was insufficient background information to make a judgement.

Review Process

A short review process was utilized to meet four objectives:

- Validate the subregional information.
- Begin discussions about the ecological implications of subregional results.
- Gain internal understanding and support of the assessment results and the process used.
- Provide feedback on information and research gaps, with suggestions for future work.

The review process primarily centered around internal audiences. External academic, research, and partner contacts were also made through a coordinated regional review process. A summary report of review comments is located in Appendix A.

[1] *Diaz, N., J. Kertis and D. Peter. 1993. Quantitative assessment of current and historic landscape structure. Unpublished manuscript. Mt. Hood National Forest, Gresham, Oregon.*

[2] *McGarigal, K. and B. Marks. FRAGSTATS unpublished software, College of Forest Sciences, Oregon State University, Corvallis, Oregon.*

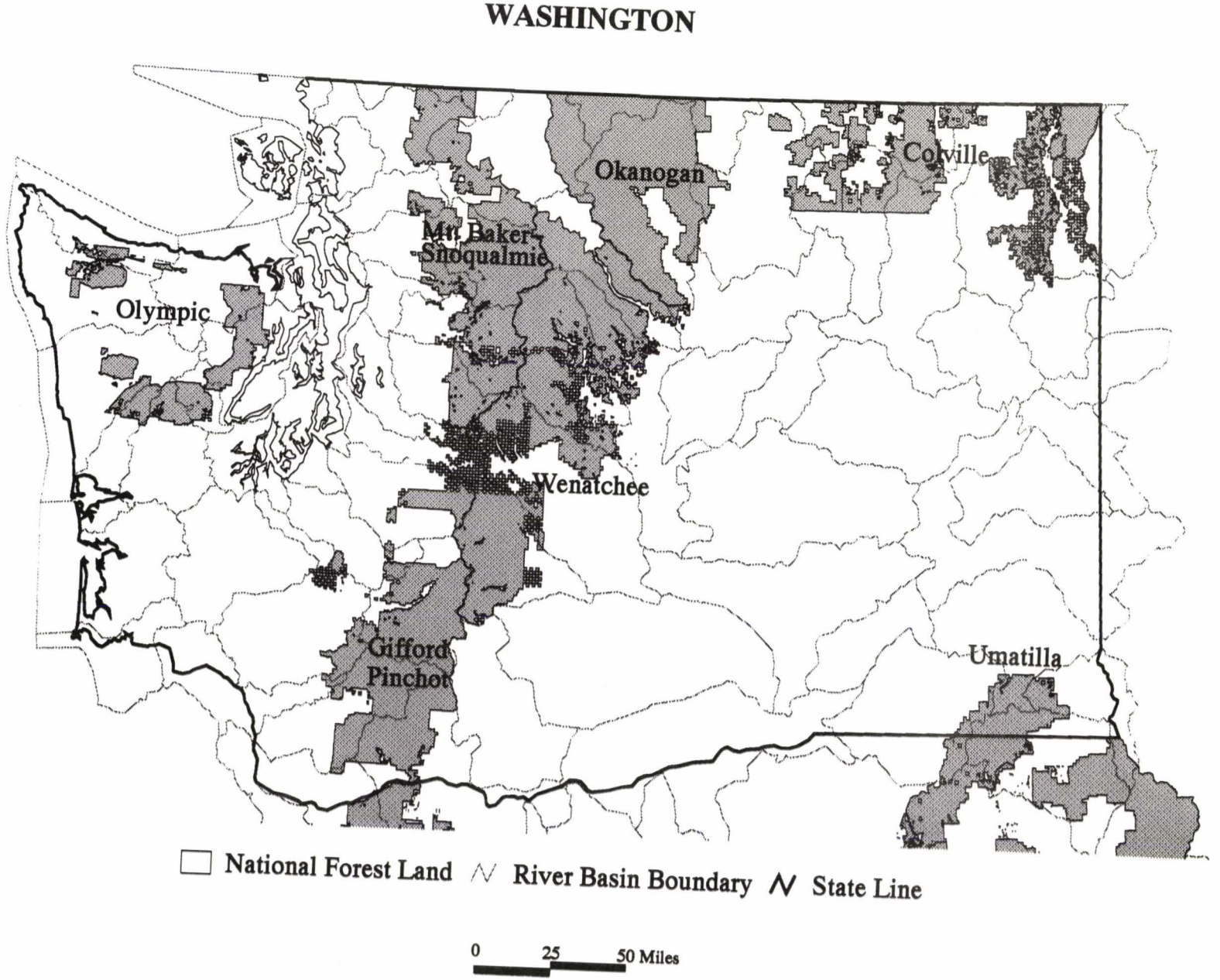


Figure 1. National Forest System lands in Washington State

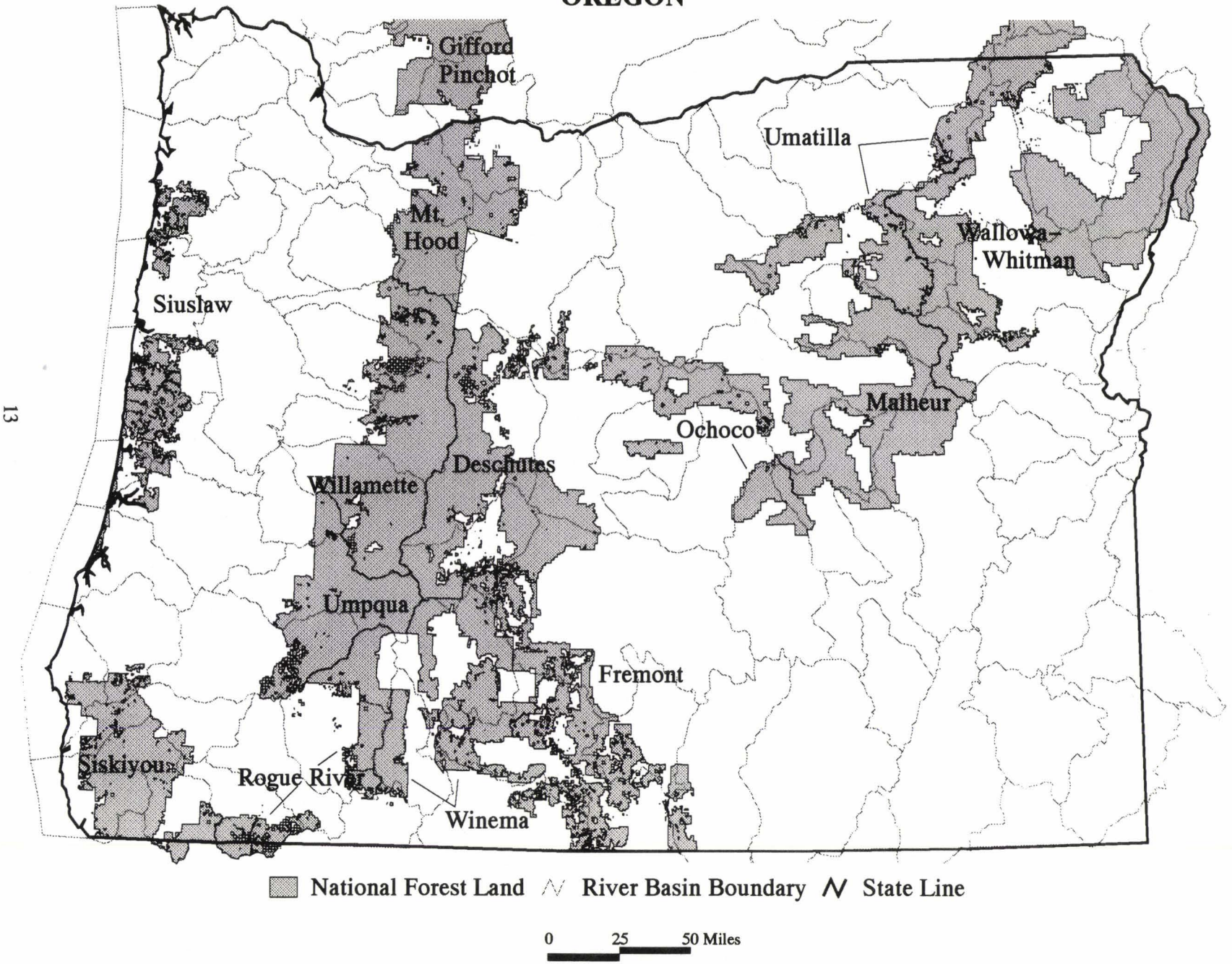


Figure 2. National Forest System lands in Oregon State

NATIONAL FOREST LAND WITH MAJOR RIVER BASINS
WASHINGTON

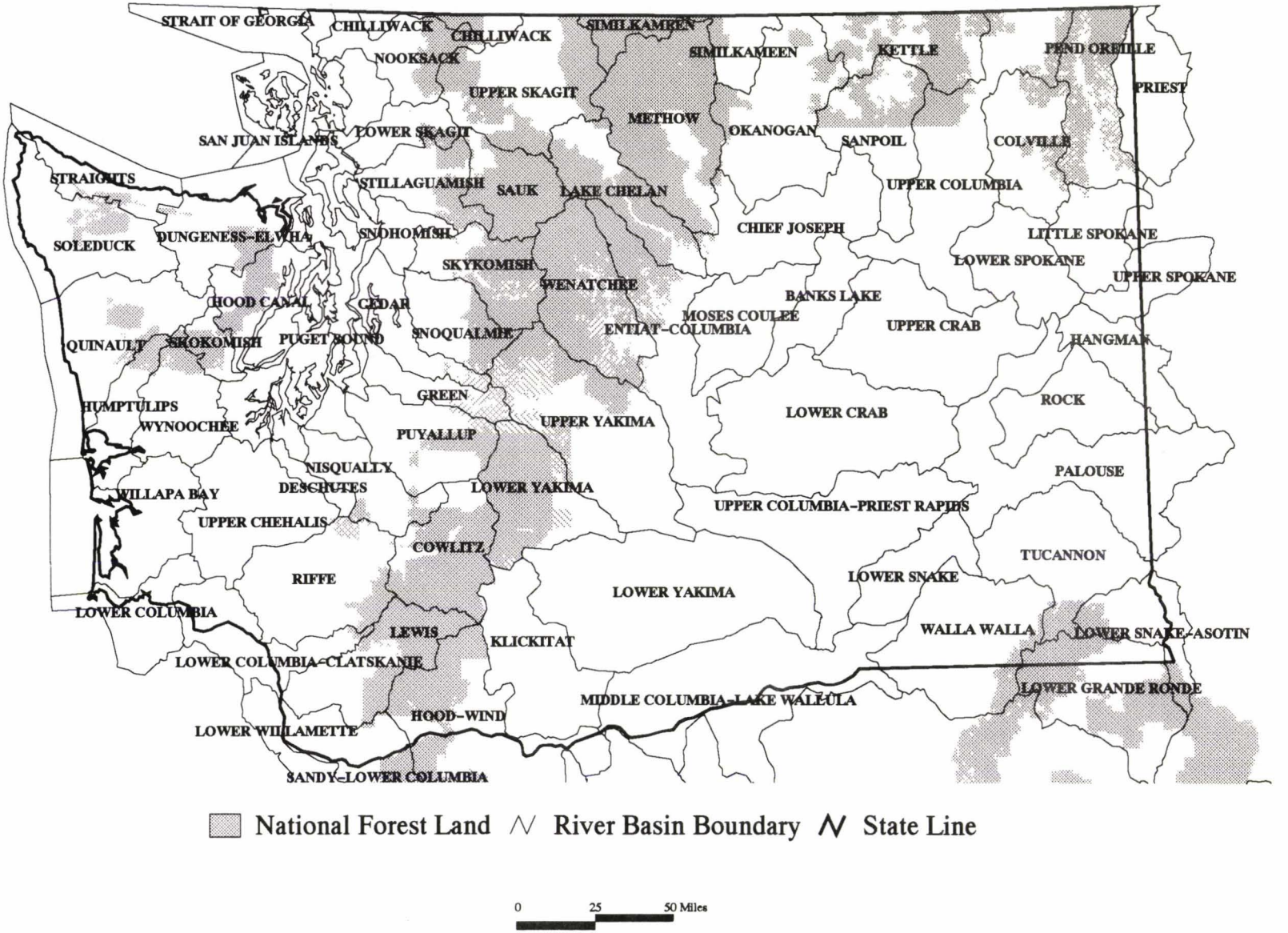


Figure 3. River Basins used for Assessment in Washington State

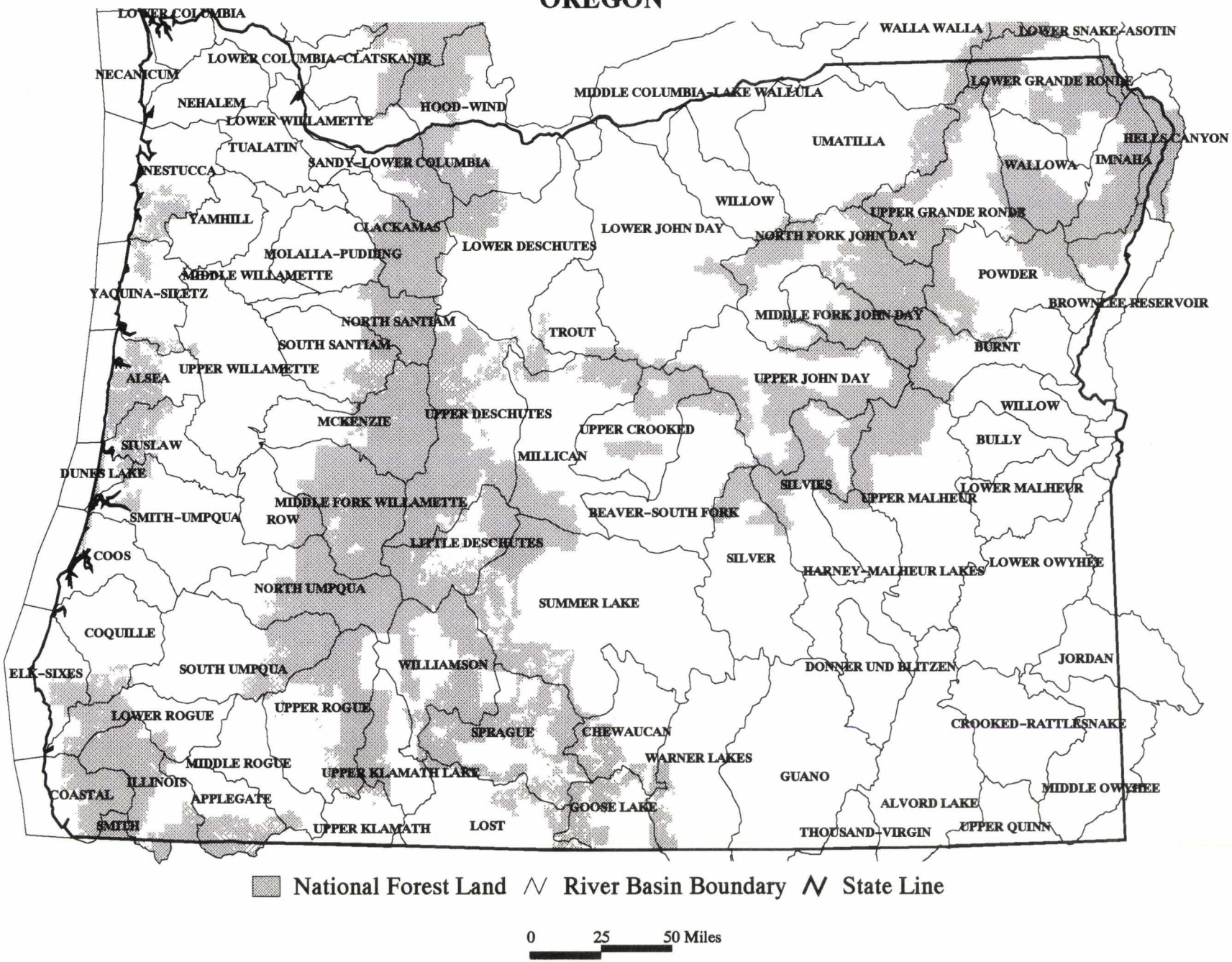


Figure 4. River Basins used for Assessment in Oregon State

Recommendations

The ecological assessment process afforded insight into future work. The participants made several recommendations on "where to go from here." All recommendations assume interagency participation, because ecosystems in the Pacific Northwest encompass many ownerships. With emphasis upon an ecological approach to forest management, these recommendations are timely and germane. The following list summarizes participant comments:

❒ Consider high priority research needs:

- Research historic and current disturbance processes, particularly fire;
- Research key ecological indicator elements.

❒ Fully implement the concept of "desired range of acceptable conditions" (desired future conditions):

- Identify elements that can be used as key indicators of ecosystem health at various scales;
- Standardize indicator element definitions and monitoring methods;
- Design GIS based systems to support indicators;
- Connect desired range of acceptable conditions with forest plans.

Research Needs

There are many more questions than answers in the new and exciting ecological approach to management. Our research efforts should concentrate on the highest priority needs first.

Research into disturbance processes is needed to better understand ecological linkages. This is especially important at larger spatial scales. Fire disturbance is primary to understanding past and current conditions in national forests and grasslands. Historic and current fire patterns (patch size, patch shape and pattern locations) need to be researched and documented. The effects of fire exclusion need to be better understood. For example, how has the buildup of fuel on the forest floor affected nutrient cycling, water availability, understory composition, wildlife habitat and productivity?

Other disturbance processes or agents of change are important influences in selected river basins. Wind disturbance, volcanic processes, and flood disturbance have had dramatic effects upon various Pacific Northwest ecosystems. Research designed to better understand these processes is also recommended.

Validation of key ecosystem health indicator elements as monitoring criteria will be needed. Assumptions and limitations linked to key ecosystem health indicators need to be thoroughly explored and adapted as improved scientific data, changes in resource conditions, or changes in legal requirements occur.

Desired Range of Acceptable Conditions

Much emphasis has been placed on the idea of desired future condition. There is strong agreement that we need to recognize and/or strive toward conditions that are desired for various landscape scales. In some cases, the conditions may already be acceptable. In all cases, there is generally a range of conditions that meet the desired format rather than a single state. For these reasons, the preference is to use the term: desired range of acceptable conditions. It is recognized that the identification of these ranges incorporates social, economic, and political desires.

In order to monitor our success or failure within a desired range of acceptable condition (DRAC), key ecological indicator elements must be identified at different spatial scales. Some of the elements used in this assessment could be used to measure DRAC; for example, maximum stream temperatures, or amount of late successional stage multilayered vegetation. The objective is to provide the best indication of acceptable conditions at various landscape scales. Suggestions of different landscape scales are: river basin, watershed, and sub-basin. Critical to the identification of key ecological indicator elements is that they occur across administrative boundaries, and that we have standards for definition, measure, database, and inventory methods.

The results of this assessment show us what ecological elements are most useful locally and regionally. One of the greatest difficulties experienced in the project resulted from variations in data sources. There are many local systems of data organization and retrieval platforms. These adaptations have been more suitable to local needs than suggested regional methods (or in some cases, there were no regional methods). The scope of our work is much greater in an ecosystem approach, geographically, administratively, and in ecological structure and function. Data must be compatible across administrative lines. Interagency standards must be in place to facilitate necessary analyses.

The key ecological indicator elements need to be supported by consistent information retrieval systems, particularly GIS databases and spatial layers. These too need to be standardized across forests and agencies in the Pacific Northwest. Often the assessment project was reliant upon TRI and ortho photo information because GIS was unavailable or not useable. It was suggested that the Pacific Northwest Region has many inventory and information sources that are designed around forest plans but they do not translate well for ecological systems. In many cases, we already have enough good data, it just needs to be organized and converted to electronic form in order to sort and filter to meet new needs.

The regional ecological assessment is primarily a qualitative analysis designed to provide a preliminary view of current conditions. Subregional areas and forests can use the results as a screen to identify river basins that have the most urgent need for finer detail ecological assessment. Ultimately, the identification of spatial desired range of acceptable conditions will be tied to forest planning. Designing DRACs will require finer resolution ecological assessment and definition of social needs before incorporating into forest plans.

Regional Terrestrial Ecosystem Results

Terrestrial ecosystems integrate the effects of climate, landform, geology and soils and reflect these in natural plant communities. Plant communities change through natural succession and through chaotic events and disturbances. Regionally, fire is an important disturbance factor. Fire regimes vary from intense, stand-replacement events every 800 years or more in very wet areas, to light underburning every 5 to 10 years in the driest areas. Although wind caused disturbance occurs periodically in forests, it is the primary disturbance factor on the wettest sites on the west side of the Olympic National Forest. Other disturbance events include volcanic activity, disease, and insects. Each of these shapes the ecosystems where they occur.

Terrestrial ecosystems are characterized by composition, structure, and function and may be measured by four components: above ground living and dead components and below ground living and dead components. This analysis focused on structure and composition at the landscape level of selected above ground components.

Landscape Composition

Ecosystem structure at the landscape level may be initially measured by different successional stages of vegetation and presence of snags. Young, or early successional, vegetation is distinctly different from mid or late successional vegetation and each plays a role in ecosystem function. The amount and distribution of these classes, including both live and dead components, can help evaluate the health of the ecosystem. Under natural conditions vegetation moves from early successional through late successional stages and back by succession and disturbance.

Early Successional Vegetation

Two perspectives of early successional vegetation were evaluated:

- early successional stage with snags and downed wood present, and
- early successional stage devoid of most large dead woody debris.

The primary sources of background information for the estimated range of natural variability in both cases were:

- fire history studies,
- ecology inventories,
- TRI (Total Resource Inventory) age structure cells,
- historical documents and accounts (i.e. Hudson Bay trappers, early settlers), and
- historical maps and photos.

Current conditions were retrieved from TRI data, Forest Plan inventories, GIS vegetation layers and other forest vegetation inventories. All teams assumed that current conditions rarely displayed the level of snags and downed wood that must have been present historically.

Across the region, where fire is the most prevalent disturbance agent, most of the basins show the amount of early successional vegetation to be within the historic range of variability. Historic ranges are wide where large, stand-replacement events occur; whole basins may be changed from late to early successional, so ranges of either could be 0 to 100 percent. In basins where wind is the primary disturbance agent, destroying small groups or single trees, or where recent volcanic eruption has occurred (a random, chaotic event), the amount of early successional vegetation is greater than the range of historic variability.

When the snags, or dead component, are considered the results are quite different. Across western Washington and Oregon the amounts of early successional vegetation with snags is substantially less than was historically present (Figure 5). Historic levels of snags in the landscape are essentially absent today.

When snags are viewed as recruitment potential for down woody material, this element is potentially low also. Down wood has many functions in an ecosystem including contributions to site productivity, acting as cover for amphibians and small rodents, providing habitat for fungi and bacteria that aid in decomposition and nutrient cycling, and acting to retain water on a site during dry periods thus aiding seedling establishment.

Late Successional Vegetation

Three perspectives of late successional vegetation were evaluated:

- late successional stage with single layered canopy,
- late successional stage with multilayered canopy, and
- acres of dense, low-vigor stands (eastside river basins only).

Information sources for the estimated range of natural variability and current late successional conditions were taken from the same sources used for early successional vegetation. Most teams correlated late successional multilayered canopy vegetation with old growth inventory data.

Late successional, single layer canopy stands result from different processes east and west of the Cascade Mountains. In western Washington and Oregon single layered stands arise after a large, stand-replacement disturbance when trees become established densely over a short period of time. These dense stands reach late successional stage before they begin to open up enough to allow other species to become established underneath. In the northern Cascades there is as much, and in the southern Cascades there is more of this type of forest than was present historically. In the Olympic Mountains the amount of this type of forest varies (Figure 6). These stands eventually form multilayered forests if undisturbed.

In eastern Washington and Oregon late successional, single layer stands are created by frequent, low intensity burns under fire resistant overstory trees such as ponderosa pine and Douglas-fir. These stands can occur in the white fir or Douglas-fir series, but still have ponderosa pine in the overstory. Lodgepole pine typically occurs as single layer stands because of the disturbance regime and reproductive strategy of the species. In ponderosa pine series and late successional, park-like stands, amounts of this type are substantially less than the historic range (Figures 7 and 8). Composition and structure of these stands has been changed as tolerant species moved into the understory and created multilayered stands. Because of the higher tree densities, growth of individual trees has been reduced. This may also have created habitat for species, such as the spotted owl, that were not historically present.

Late successional multilayered canopy stands occur as the result of succession sometimes with light underburns opening the canopy enough to allow other species to become established. In western Washington and Oregon amounts of this stand structure are less than or near the lower end of historical range (Figure 9). Species that rely on this type of structure may have reduced populations. On the eastside of the Cascades late successional, multilayered stands are within or above historic range, likely the result of fire exclusion.

In the forested areas of eastern Washington and Oregon the amount of high density, low vigor stands shows no apparent trend across all basins.

Ecosystems Considered by Plant Series

Forested ecosystems can be divided into smaller systems based on the climax tree species on that site. This is known as the plant series. For example, western hemlock (Tsuga heterophylla) series represents warm, moist systems; silver fir (Abies amabilis) series represents cool, moist systems; and mountain hemlock (Tsuga mertensiana) series represents cold, moist systems, west of the Cascades. East of the Cascades, the ponderosa pine (Pinus ponderosa) series is warm and dry; the lodgepole pine (Pinus contorta) series relatively moist and cool to cold; and the white fir (Abies concolor) series is intermediate.

Western hemlock ecosystems in the central Coast Range have less than historic conditions of late successional, multilayered canopy stands, while the Olympic has several basins that are substantially below, several within, and a few above historic range of conditions. Along the Cascades this series has predominantly less late successional, multilayered stands than were historically present (Figure 12). Early successional and late successional, single layer stands are at the lower end of historic conditions (Figures 10 and 11).

Silver fir ecosystems show predominantly less late successional, multilayered canopy stands than historically were present in the Cascades. In the Olympic, conditions are less than or within historic ranges. The amount of early successional stands is less than or at the lower end of historic range, and the late successional, single layer stands are within or at the lower end (Figures 13-15).

Mountain hemlock systems exhibit less late successional multilayered stands in the north Cascades. In the central Cascades this series is within the range of natural variability or greater. In the Olympic National Forest amounts are variable by basin. Late successional, single layer stands are variable, and early successional stands are at the lower end of historic conditions (Figures 16-18).

When the terrestrial ecosystems are broken down by plant series, it becomes apparent that late successional multilayered stands in the warm, moist ecosystems (western hemlock) and the cool, moist ecosystems (silver fir) have been impacted (the proportions have been reduced), as opposed to those in the colder systems (mountain hemlock). If the objective is to restore natural proportions, amounts of late successional multilayer stands in the western hemlock and silver fir series would be increased.

In eastern Oregon, single layer, late successional stands in the ponderosa pine and Douglas-fir ecosystems are generally less than the historic range (Figures 7 and 8). Restoration to historic conditions may result in increased amounts of stands with this structure.

Nonforest areas in eastern Oregon are also changing. Juniper woodlands are increasing in size while shrub-steppe communities are decreasing. Existing shrub steppe communities are moving toward late successional vegetation. Grasslands are also decreasing in amount.

Landscape Pattern

Across Washington and Oregon, forest landscape composition has changed markedly. Qualitative assessments report current conditions are characterized by many, relatively small, dispersed, early successional patches. Late successional vegetation has been broken up and amounts of interior forest habitat have decreased. Amounts of edge between early and late successional vegetation have increased, and the contrast is high; that is, the transition is abrupt between young and old stands. East of the Cascades, where river basins tend to have lower fire return intervals, landscape patterns are also different. Intensively managed basins have become more diverse and fragmented, while other wilderness basins have become less diverse and are less fragmented (simplified).

Quantitative Analysis

Several basins were chosen for quantitative analysis of landscape composition (Diaz, Kertis and Peter, unpublished). Nine westside landscapes were selected representing a range of conditions where stand-replacement fires are a dominant factor in the creation of landscape patterns. Of these, three river basins are shown in Figure 19; the Wynoochee in the Olympic National Forest, the North Fork of the Siuslaw in the Siuslaw National Forest, and Oak Grove Fork in the Mt. Hood National Forest.

Figure 19 shows basic landscape structures in (gray) matrix and (white) patch openings. The matrix is the most continuous portion of the landscape; for example, mature forest is commonly the matrix in the Pacific Northwest. The matrix is important because it affects the rate at which various disturbances move through the landscape. It also determines the ability of organisms to move across or persist in portions of the landscape, and overall species diversity. Patches are areas that differ from the matrix; for example, harvested areas are patches or openings in a mature forest matrix.

The analysis compared landscape structure for two approximate time periods, 1890 and 1990. The former represented "natural" conditions and could be reconstructed from the ages of existing mature stands, while the latter represented current condition.

At the landscape level, in all cases, there are more openings in the current landscapes and they are 1.3 to 10 times smaller than natural openings. In general, variability in the size of openings has decreased (patches are becoming more uniformly-sized), but there is still a high degree of variation. The density of openings has increased, indicating that the landscape is less uniform or more heterogeneous, than in the past. Except in the Coast Range landscape, there has been an increase in the amount of edge, the forest to opening interface.

Significant and obvious differences exist between the Siuslaw National Forest landscapes and the others, due to the large Coast Range fires close to the 1890 benchmark (Figure 19). For example, the amount of mature forest has increased, open patches have decreased in total area. This highlights the problem of using only one point in time to conduct this type of analysis -- the results may be different depending on the stage of recovery from major disturbance events. The landscapes in the Olympic and Cascade Mountain forests show that amount of mature forest and opening size have decreased. There are a greater number of openings and less mature forest core area currently than in 1890, reflecting a higher degree of fragmentation. Patches of mature forest are also becoming increasingly isolated from each other. In the Coast Range, openings have decreased in total area, while openings have been coalescing and getting larger in other landscapes.

The consistency of the trends in these data are very striking, as is the significance of the recency of disturbance in the Siuslaw landscape. Even though these landscapes represent very different ecosystems within the western portion of the Pacific Northwest Region, the changes from 1890 to 1990 are clearly in a common direction. To get a true picture of the nature of change through time, landscape structure analysis should use several points in time. This will integrate the fluctuations that occur as landscapes are disturbed and recover.

Figure 5. Historic range and current percent of river basin area (western Washington and Oregon) in early successional vegetation. Missing and incomplete information is due to lack of inventory data.

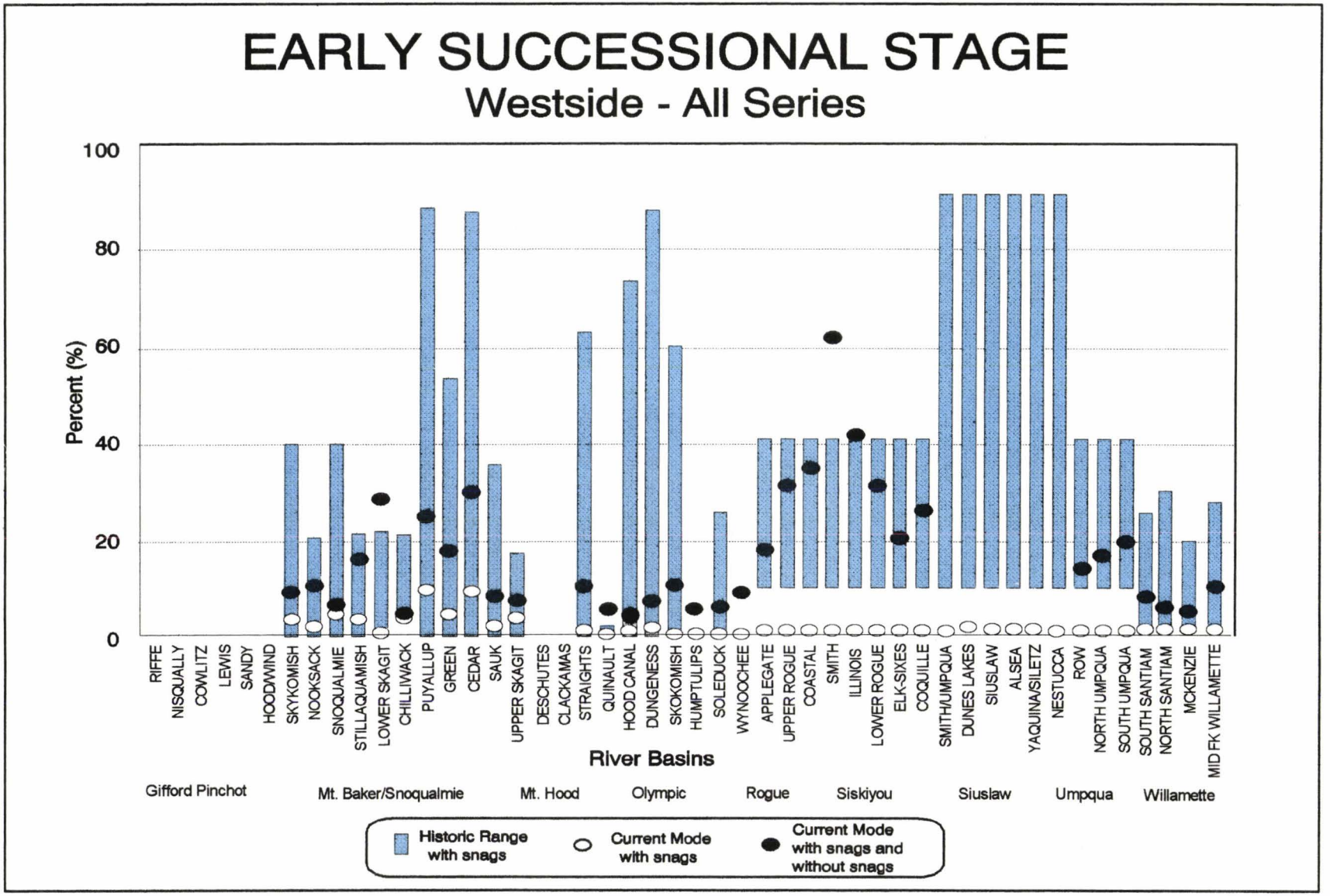


Figure 6. Historic range and current percent of river basin area (western Washington and Oregon) in late successional, single layer canopy stands. Missing and incomplete information is due to lack of inventory data.

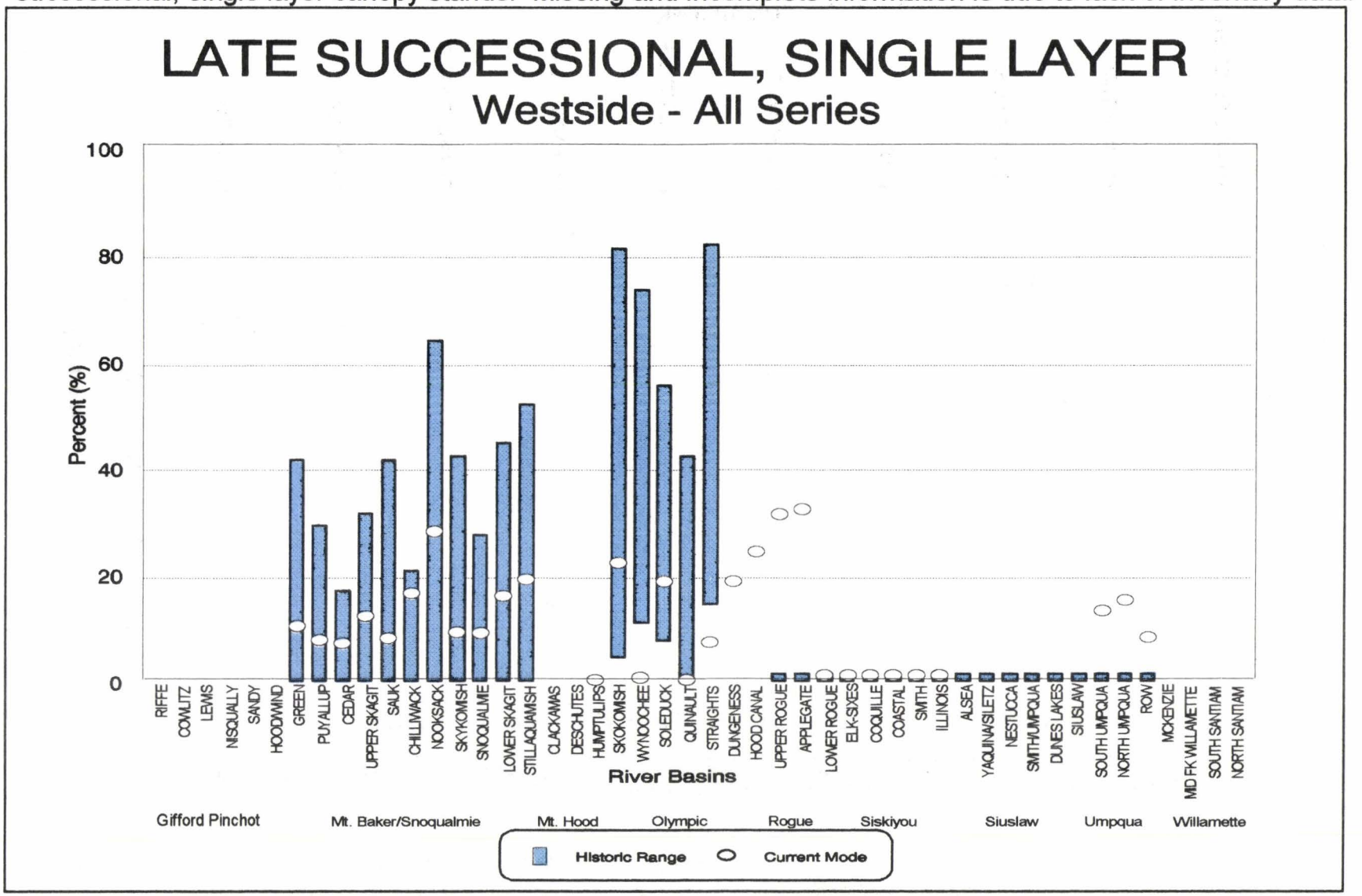


Figure 7. Historic range and current percent of river basin area (central Oregon) in late successional, single layer canopy stands in the ponderosa pine series.

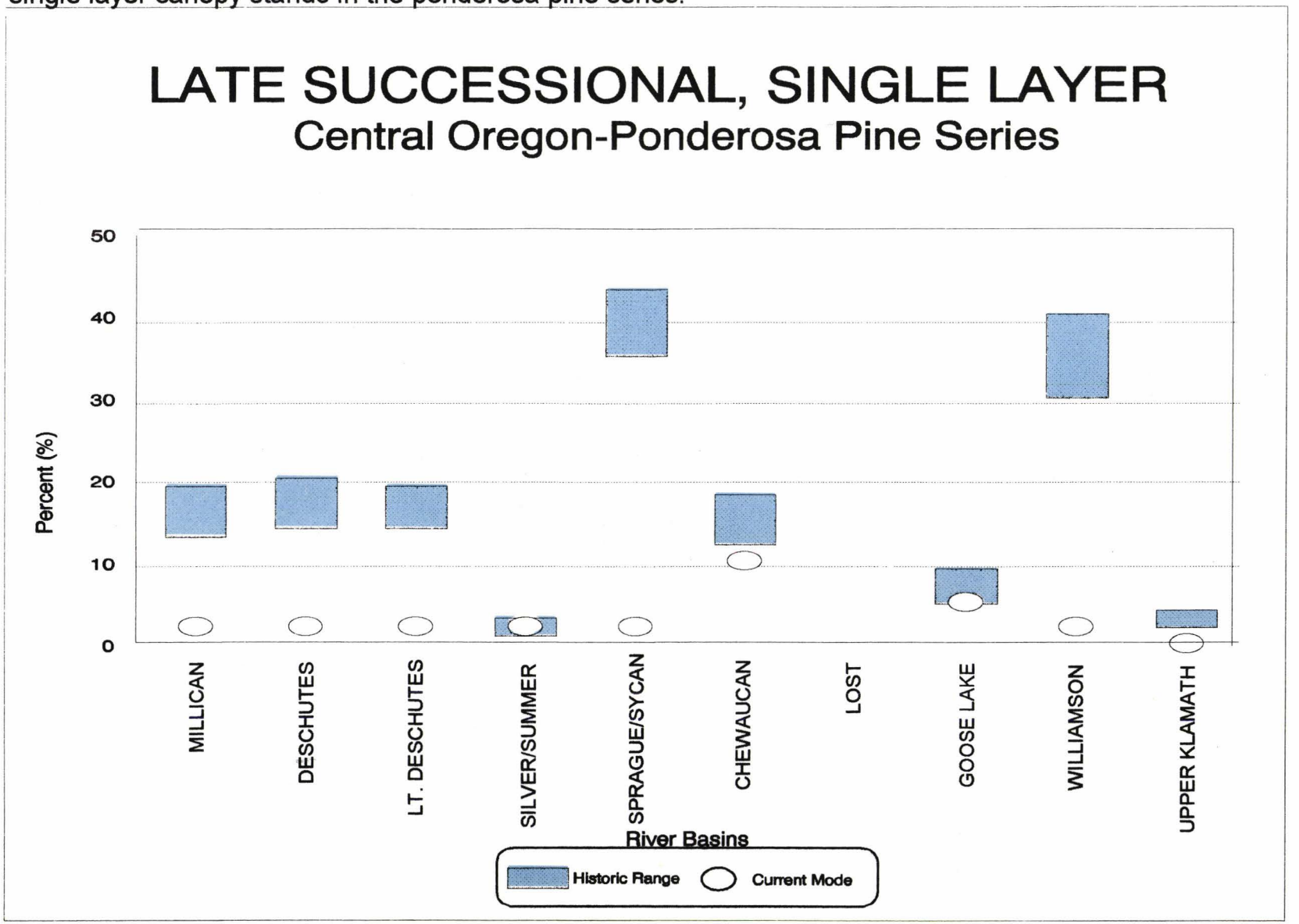


Figure 8. Historic range and current percent of river basin area (eastern Oregon) in late successional park-like stands. Data taken from Restoring Ecosystems in the Blue Mountains (Caraher 1992) and Ochoco Amendment (1992).

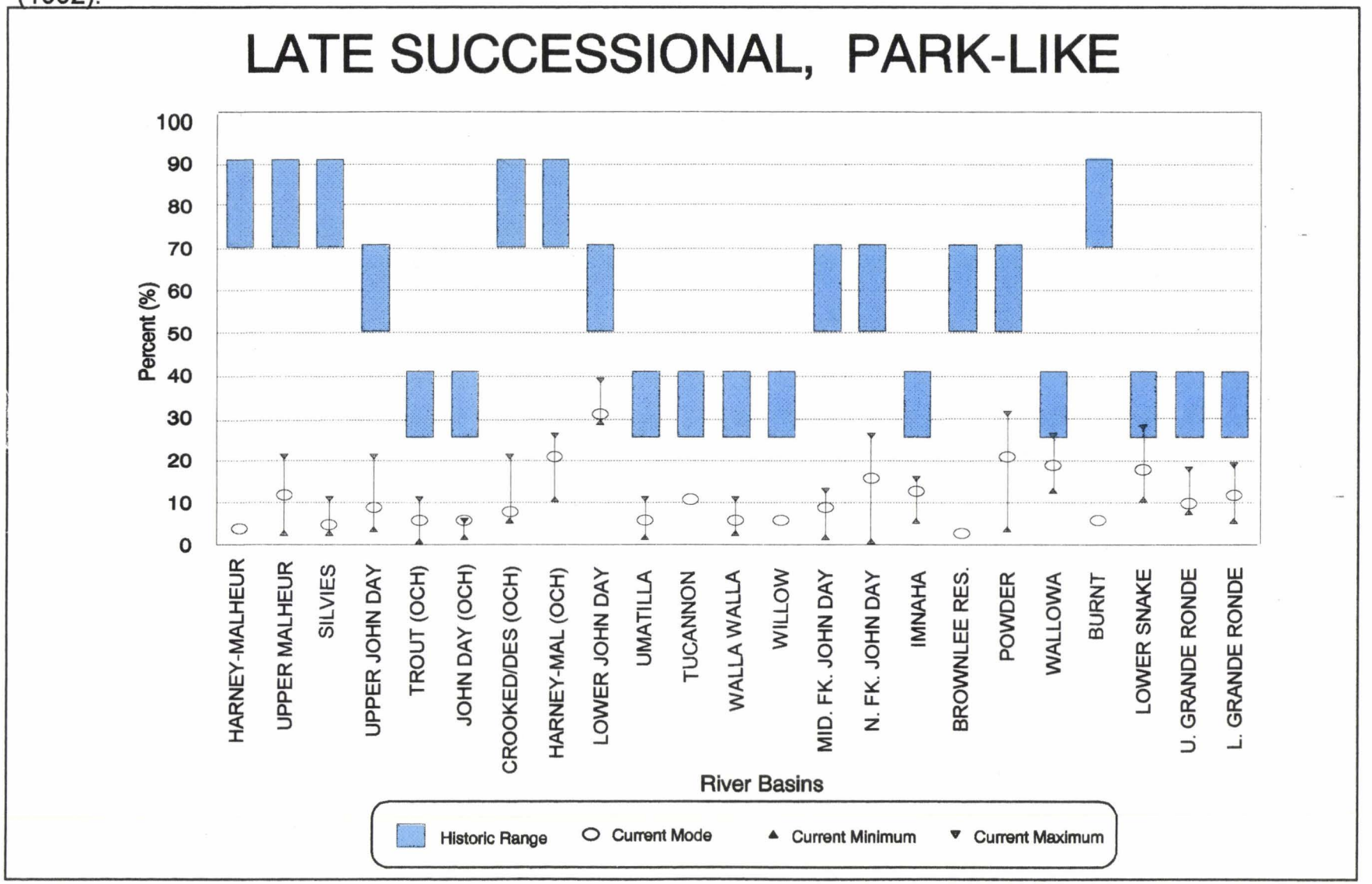


Figure 9. Historic range and current percent of river basin area (western Washington and Oregon) in late successional, multilayered canopy stands. Missing and incomplete information is due to lack of inventory data.

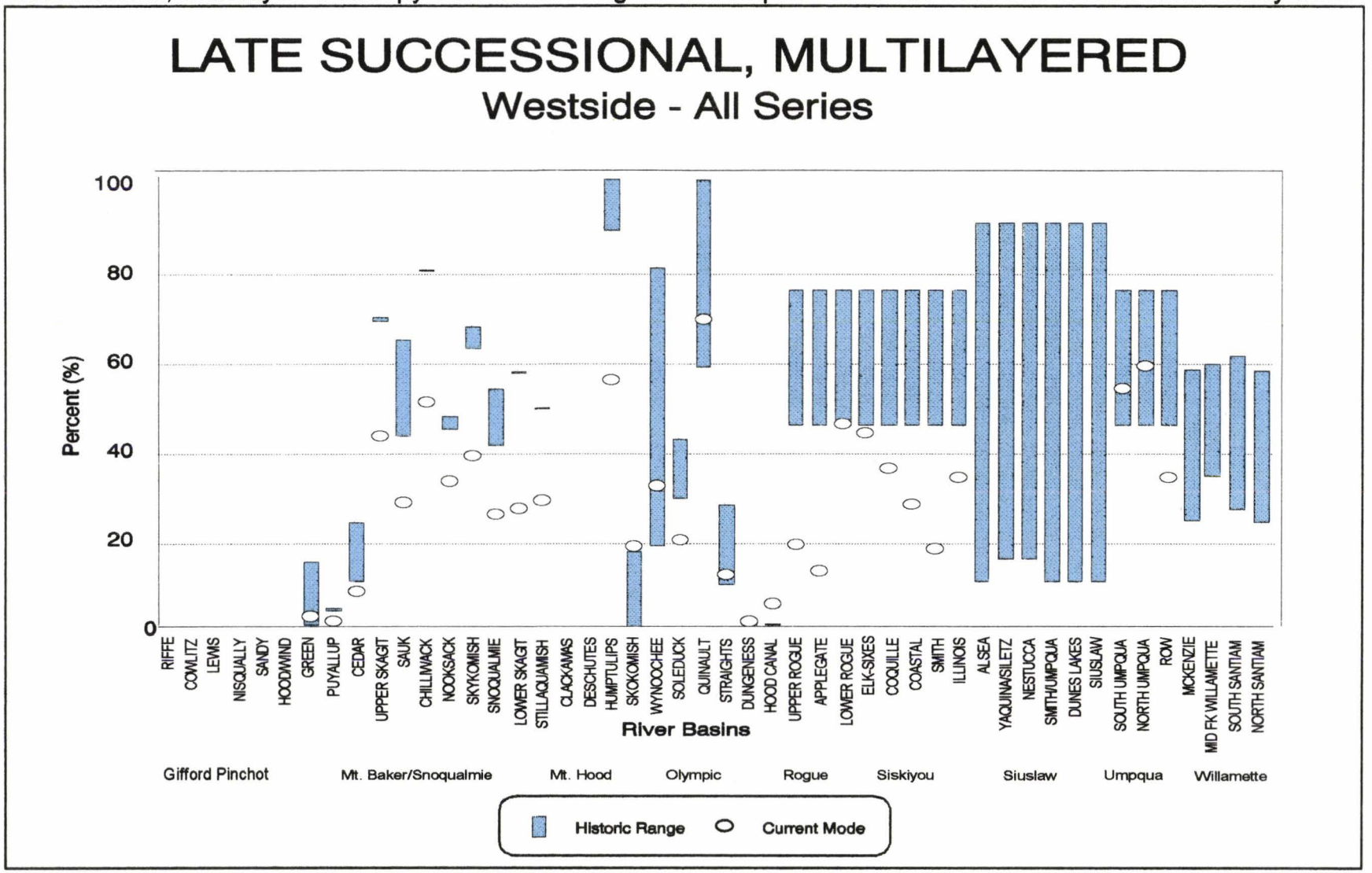


Figure 10. Historic range and current percent of river basin area (western Washington and Oregon) in the western hemlock series with early successional vegetation. Missing and incomplete information is due to lack of series in river basin, or lack of inventory data.

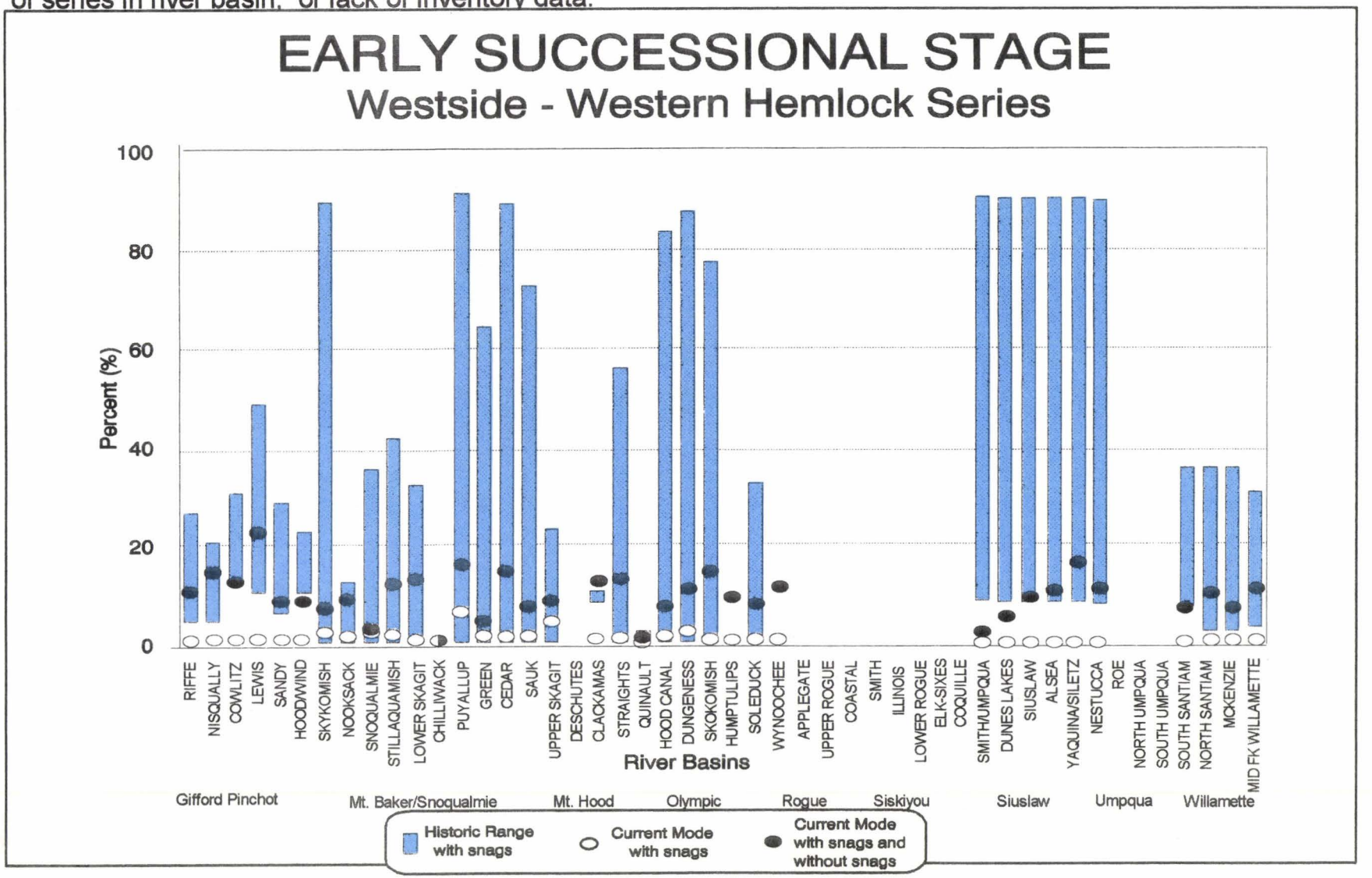


Figure 11. Historic range and current percent of river basin area (western Washington and Oregon) in the western hemlock series with late successional, single layer canopy stands. Missing and incomplete information is due to lack of series in river basin, or lack of inventory data.

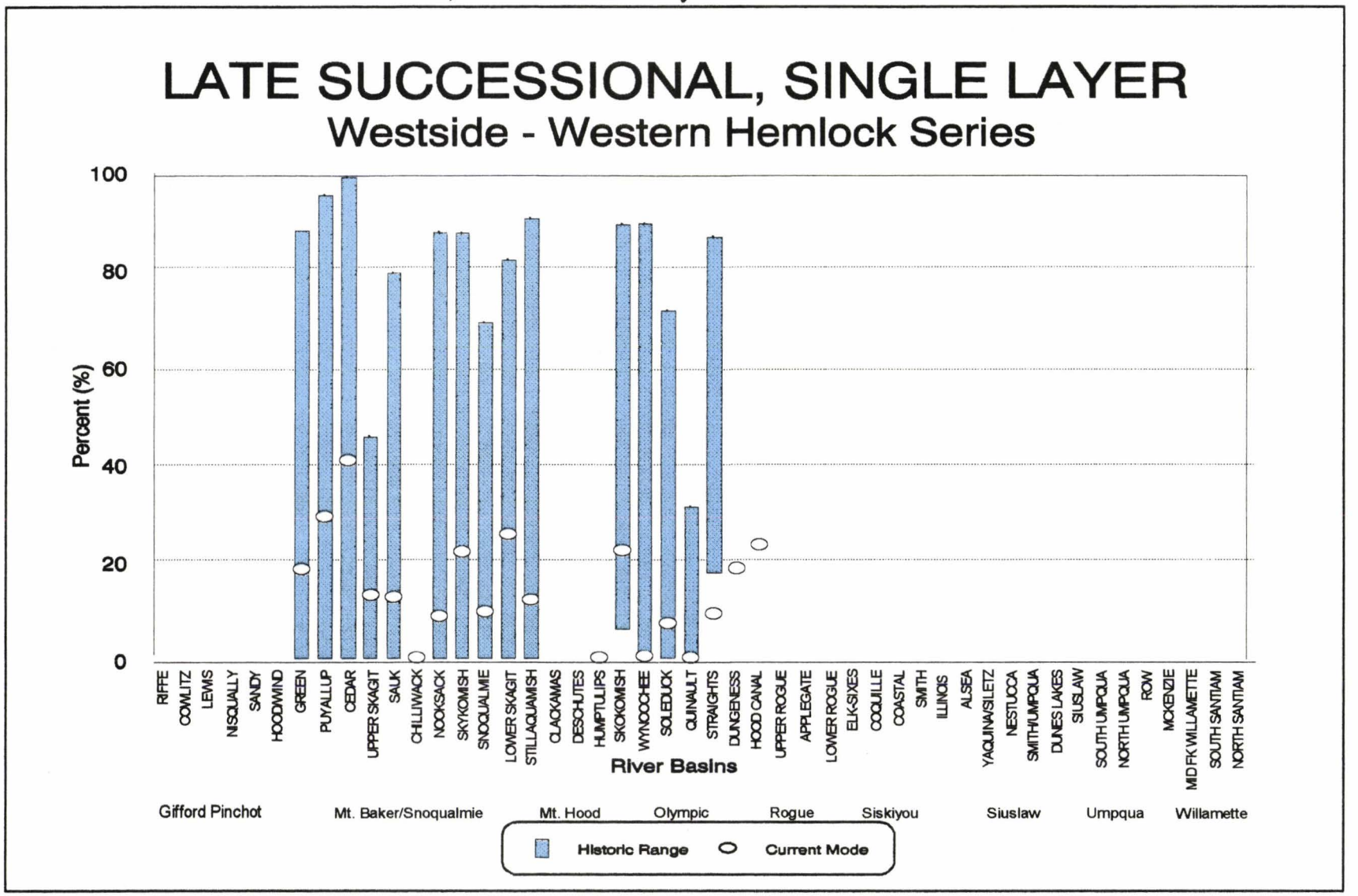


Figure 12. Historic range and current percent of river basin area (western Washington and Oregon) in the western hemlock series with late successional, multilayered canopy stands. Missing and incomplete information is due to lack of series in river basin, or lack of inventory data.

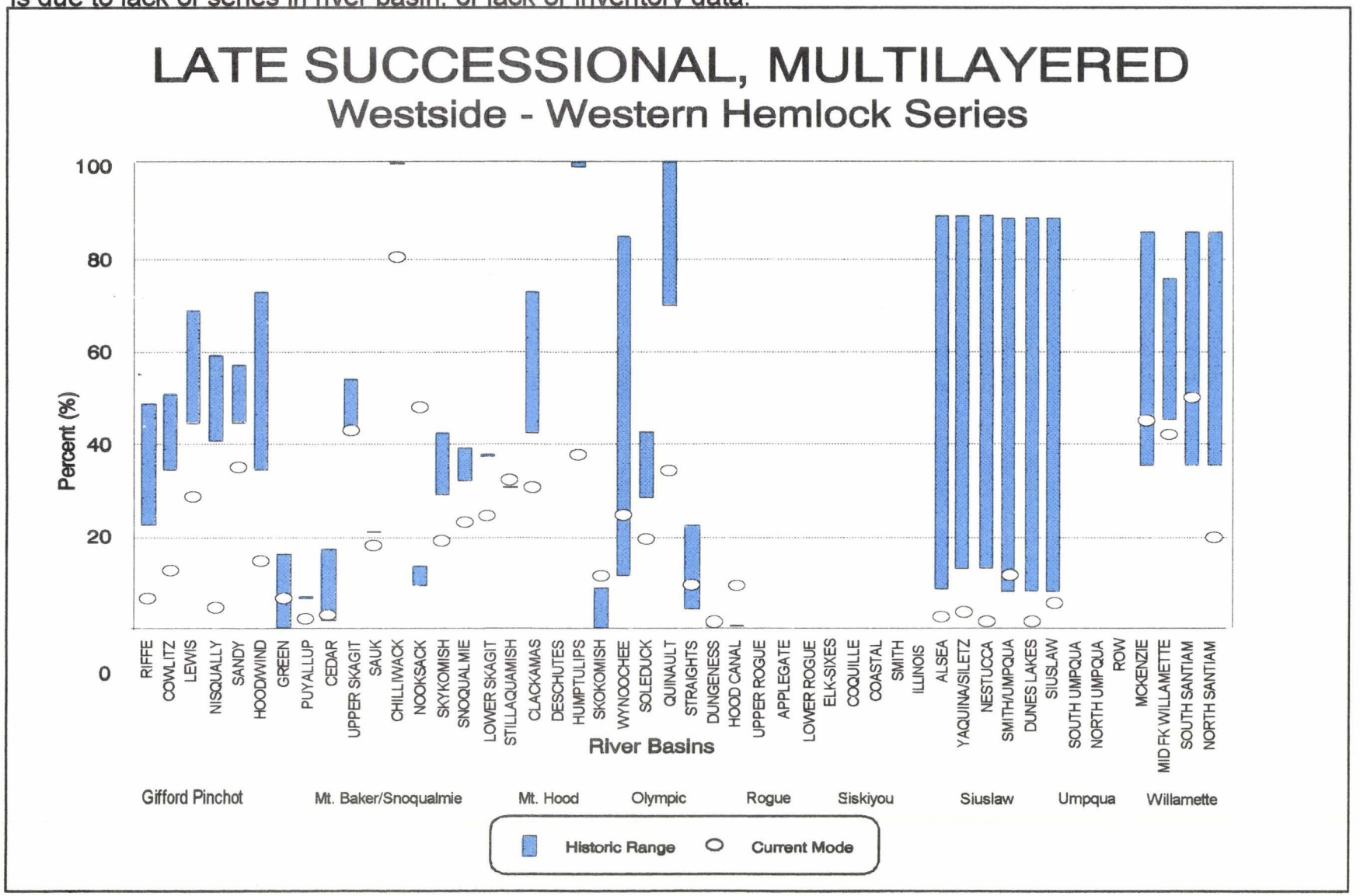


Figure 13. Historic range and current percent of river basin area (western Washington and Oregon) in the silver fir series with early successional vegetation. Missing and incomplete information is due to lack of series in river basin, or lack of inventory data.

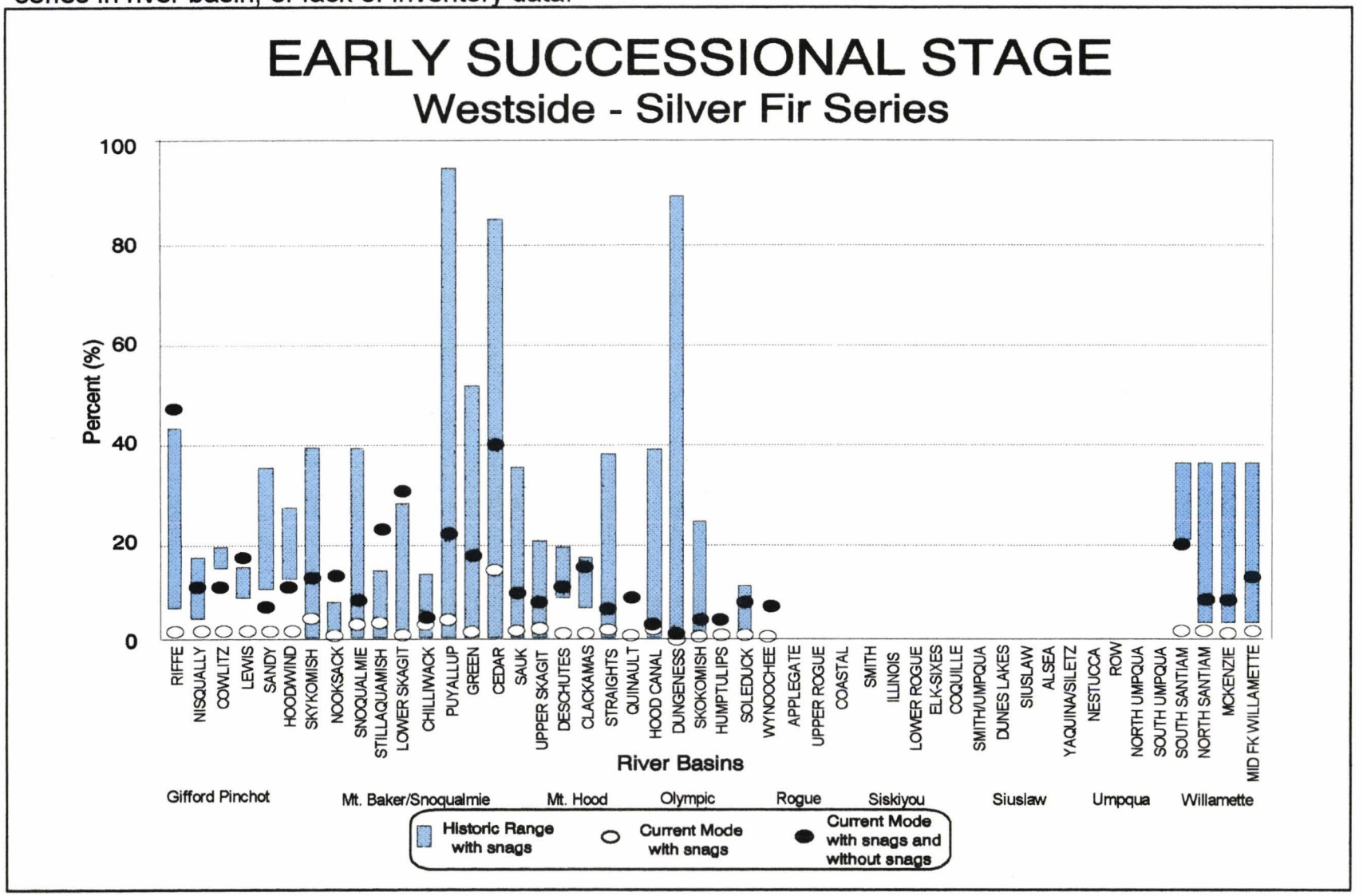


Figure 14. Historic range and current percent of river basin area (western Washington and Oregon) in the silver fir series with late successional, single layer canopy stands. Missing and incomplete information is due to lack of series in river basin, or lack of inventory data.

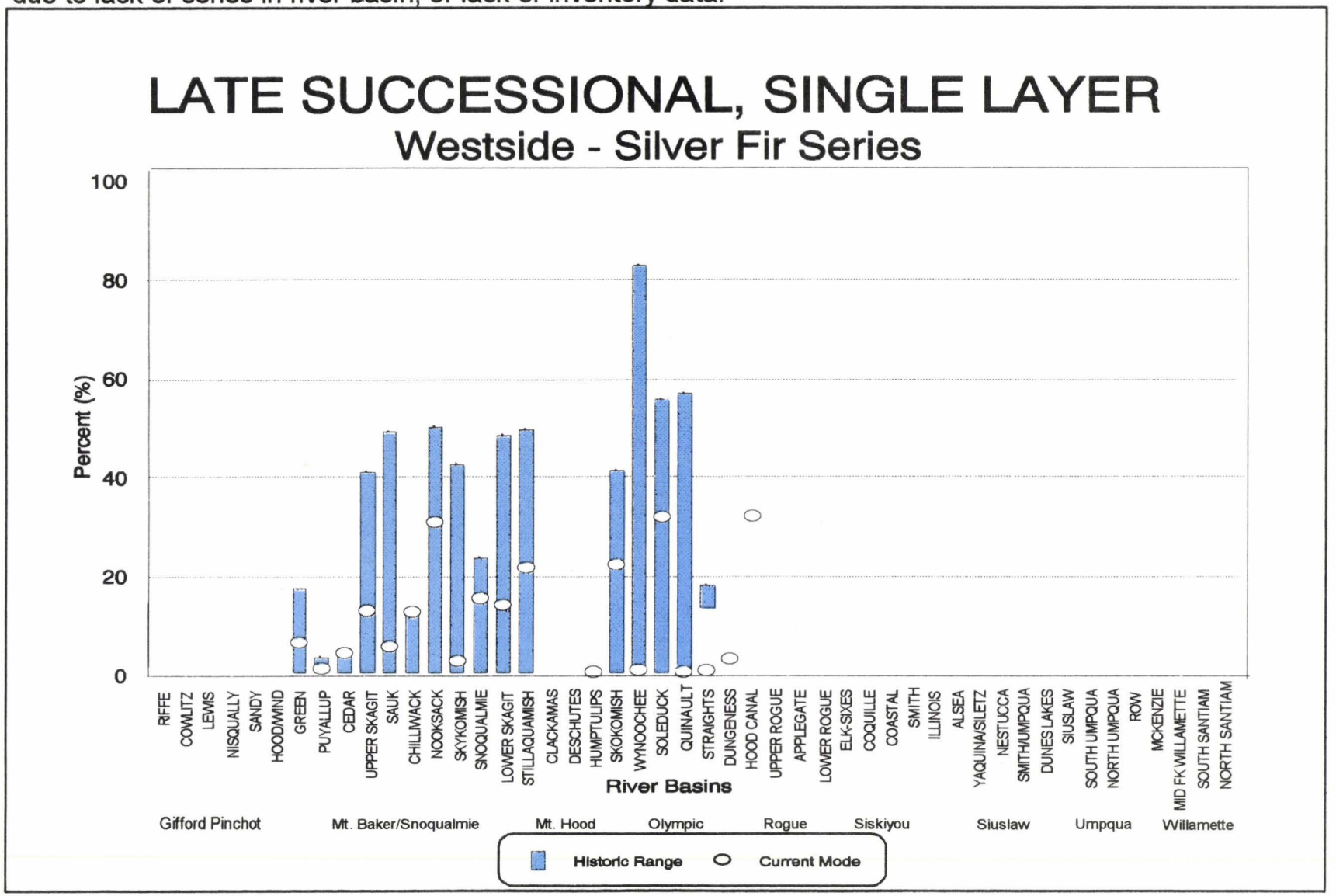


Figure 15. Historic range and current percent of river basin area (western Washington and Oregon) in the silver fir series with late successional, multilayered canopy stands. Missing and incomplete information is due to lack of series in river basin, or lack of inventory data.

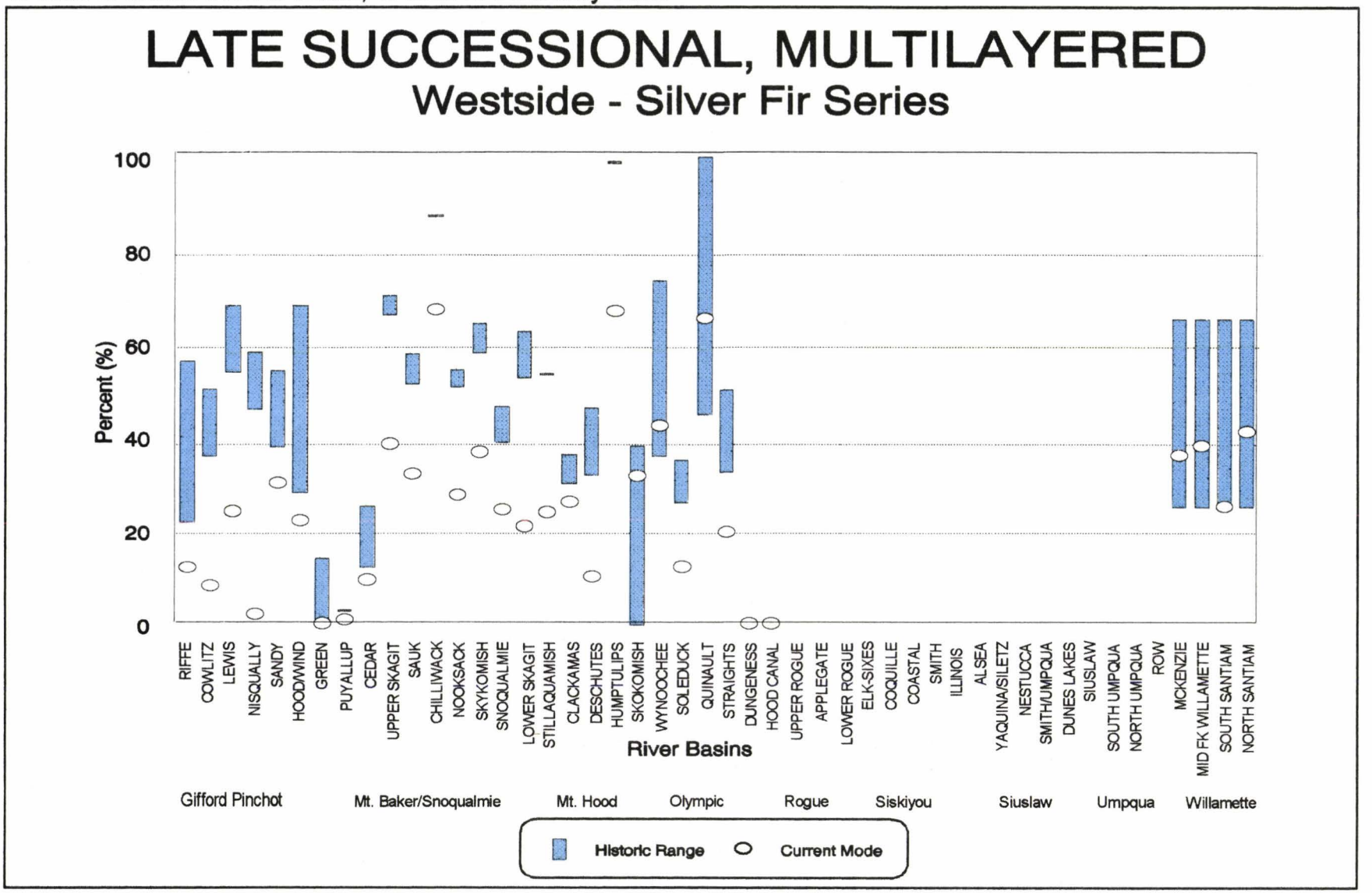


Figure 16. Historic range and current percent of river basin area (western Washington and Oregon) in the mountain hemlock series with early successional vegetation. Missing and incomplete information is due to lack of series in river basin, or lack of inventory data.

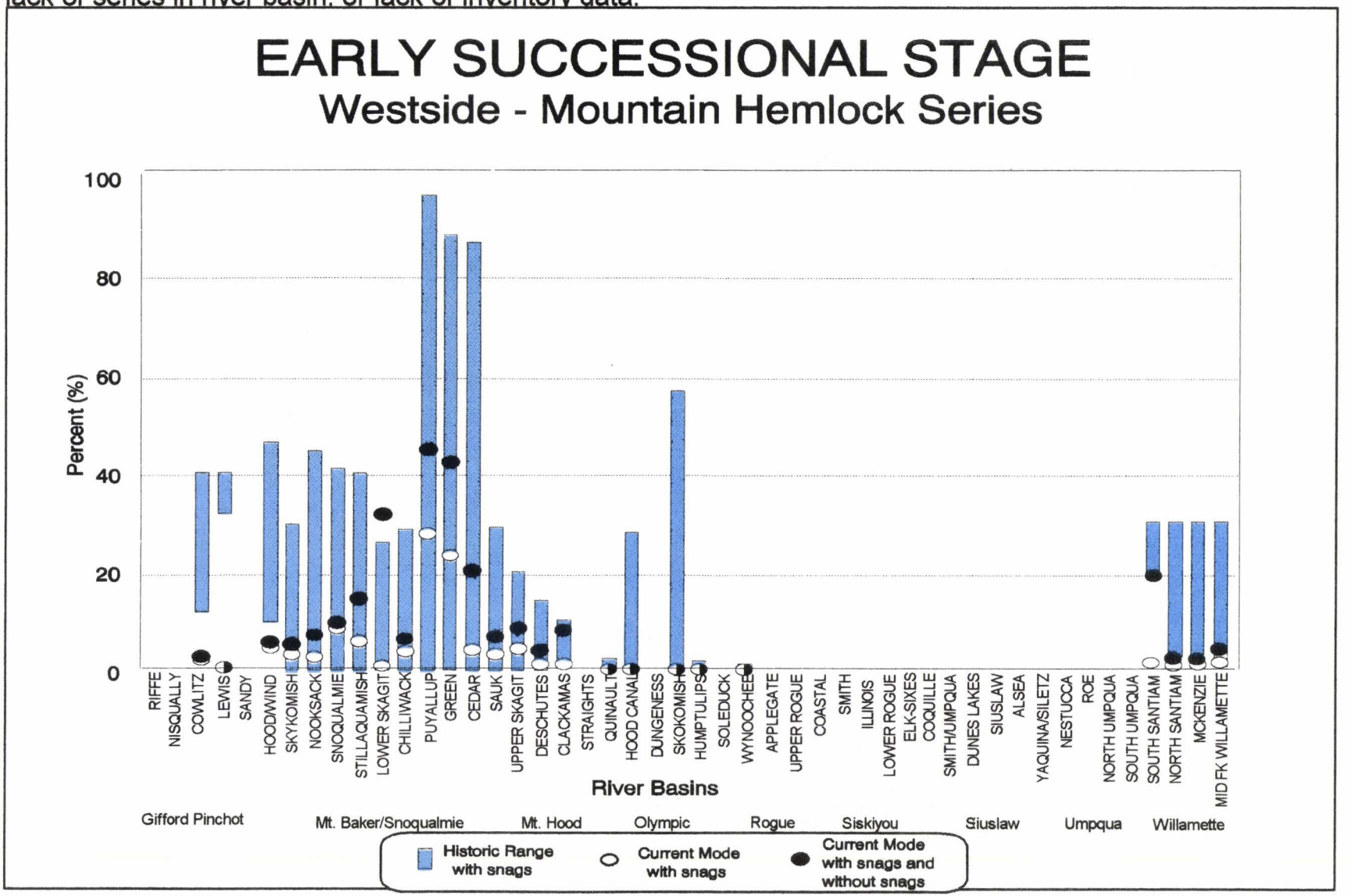


Figure 17. Historic range and current percent of river basin area (western Washington and Oregon) in the mountain hemlock series with late successional, single layer canopy stands. Missing and incomplete information is due to lack of series in river basin, or lack of inventory data.

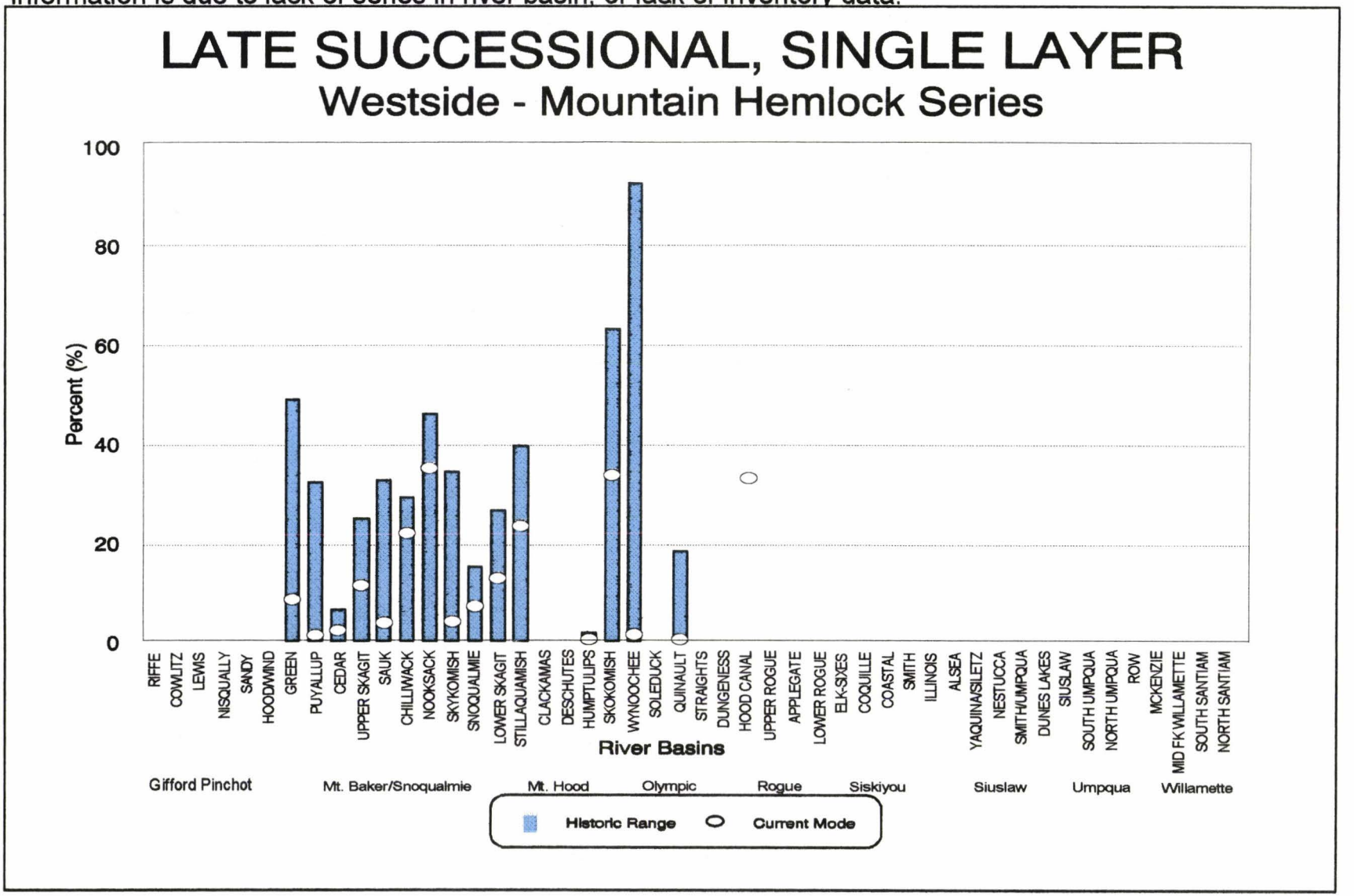


Figure 18. Historic range and current percent of river basin area (western Washington and Oregon) in the mountain hemlock series with late successional, multilayered canopy stands. Missing and incomplete information is due to lack of series in river basin, or lack of inventory data.

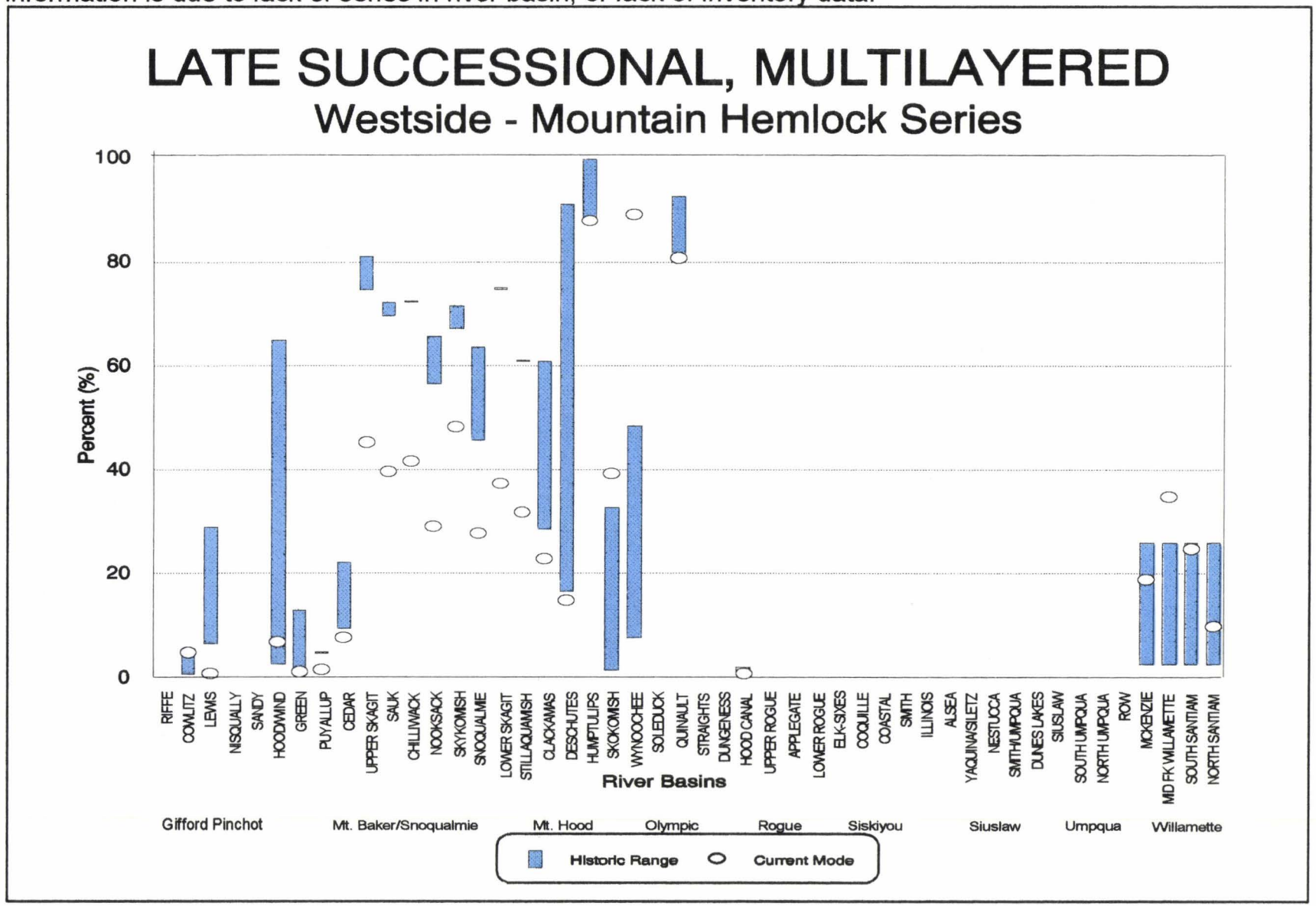
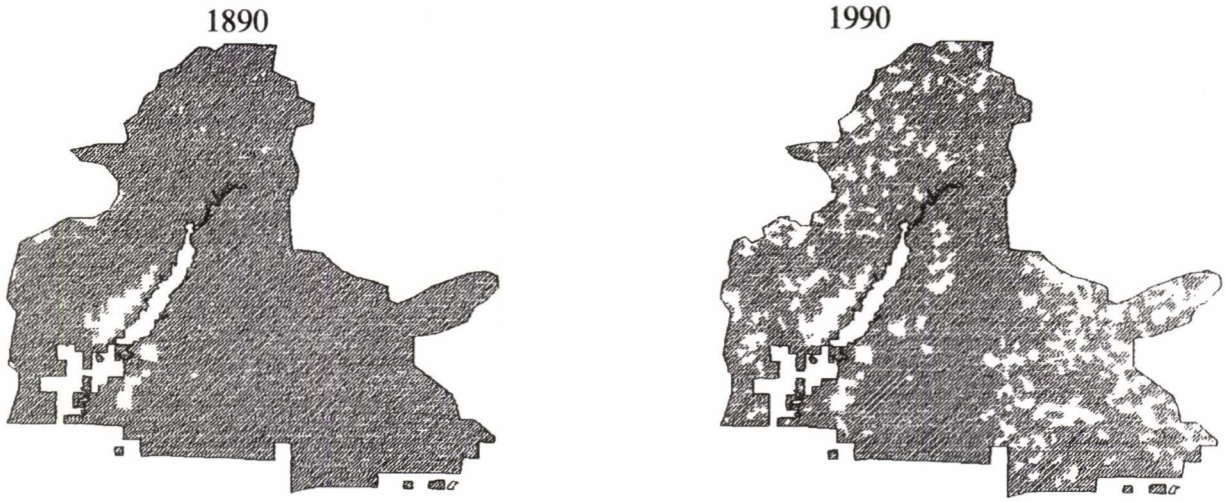
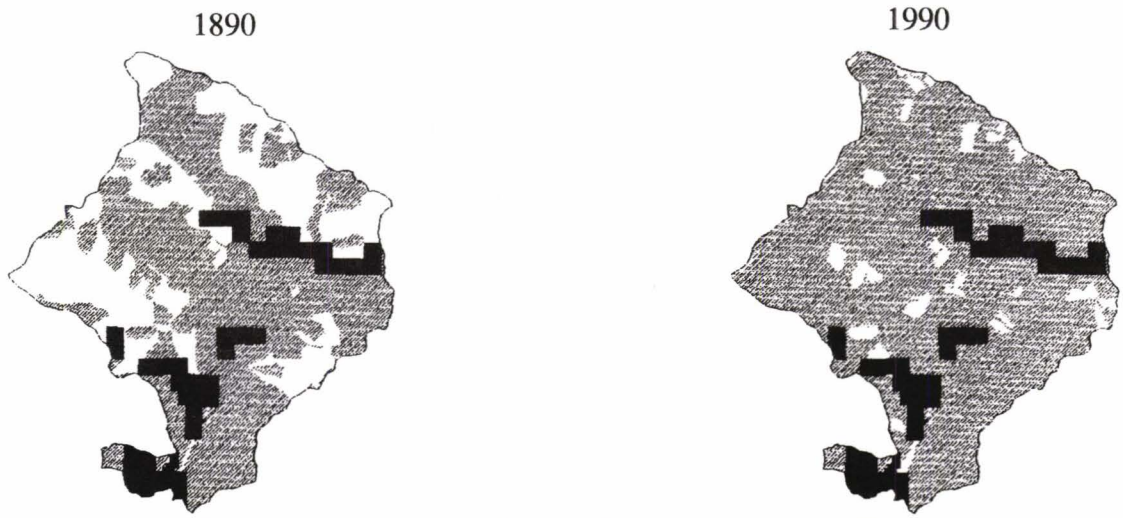


Figure 19. Patterns of the Wynoochee, Oak Grove Fork, and North Fork Siuslaw landscapes in 1890 (pre-European settlement) and 1990.



Matrix and patches, Wynoochee landscape (OLY)

Matrix and patches, Oak Grove Fork landscape (MTH)



Matrix and patches, North Fork Siuslaw landscape (SIU)

Open patch
(natural or created openings)

Matrix
(closed canopy conifer forest)

Private land

Regional Aquatic and Riparian Ecosystem Summary

Conditions of streamflow, sediment yield, watershed and channel stability, water quality, and aquatic habitat are all important measures of the hydrologic function of a watershed. While we could not directly measure all of these components, we did select diagnostic elements for which current data was available. Five attributes were used to characterize "average" riparian and aquatic ecosystem conditions for National Forest lands at the river basin scale. The methods section describes each measure. The Blue Mountain Forests, in conjunction with the Ochoco National Forest, evaluated different elements for their assessments and reached conclusions similar to those of this regional assessment. Together, these assessments provide several conclusions about riparian and aquatic ecosystems in the Pacific Northwest Region.

Aquatic and riparian conditions are directly influenced by hillslope processes and characteristics. The dominant concerns related to hillslope features center on the potential for hydrologic change resulting from various forms of disturbance: vegetative change, compaction, and increased mass failure.

Percent of River Basin Disturbed

Results of this measure are variable. In some cases, natural disturbance created more openings (early successional stage) than currently exist. This measure was selected to provide information on the change in ground cover and infiltration capacity of the river basin. This is important since ground cover controls infiltration and surface runoff. Compacted surfaces exhibit rapid runoff. Impaired infiltration tends to route runoff and sediment into streams. Landslide frequency may be affected by roads and vegetative treatment. An increase in roads and ground-based harvest has generally caused greater disturbance in eastside forests than westside.

Information sources for the historical percent of river basin disturbed included forest soil resource inventories and terrestrial ecosystem data. Historic soils were assumed to have no compaction. Current conditions included the amount of system roads, including cut slopes, running surface, and fill slopes. The amount of area altered as a result of ground-based skidding and mechanical fuel treatment was also considered as currently disturbed.

Most river basins have experienced an increase of impermeable and disturbed ground on westside forests, but in most cases this increase is not a significant problem. Several specialists did not feel that this measure adequately covered the problem of sedimentation in westside streams and that it should be better addressed in future assessments.

Two primary indicators of aquatic condition are maximum water temperature and the frequency of large pools within the channels of a river basin.

Pool Frequency

This measure provides one view of channel conditions. See Figures 20 to 22. Pools are necessary for litter and debris collection that provides food for invertebrate organisms. The range of natural variability estimates for the pool frequency measure are taken from Pacific Salmon and Steelhead Habitat Management Strategy (PACFISH) data representing "good fish habitat". The PACFISH effort was initiated by the Chief of the Forest Service to address management of selected fish species, focusing upon habitat conditions that contribute to their recovery. A reduction of pools on intermediate size tributaries is most often associated with one or more of the following: loss of in-channel structure such as large wood, increased sediment (particularly bed load), and/or straightening of the channel. Reduced pools equate to a loss of fish habitat and populations. The delivery mechanisms of large woody debris which enhance pool formation have been interrupted in many cases. Results of this assessment suggest a general "simplification" of aquatic and riparian ecosystems. Channel complexity is decreasing as evidenced by a reduction of pools. Clearly, some streams are more resilient than others.

Current pool frequency information was gathered from forest stream inventoryes, research data, and from data available from other agencies.

Maximum Stream Temperature

Assessment results indicate a general increase in maximum water temperature across most river basins. See Figures 23 to 26. This is typically associated with the loss of riparian shade and/or channel widening caused by a loss of in-channel structure, increased sediment, or reduced bank stability.

Various sources of information were used to establish the range of natural variability for maximum stream temperatures. Knowledge of stream temperatures flowing from wilderness and other relatively unaltered landscapes were extrapolated to meet river basin scale. In some cases, estimates were based upon knowledge of historic and existing fish populations.

Current maximum stream temperatures were gathered primarily from forest stream inventories. When no other information sources existed, groundwater temperatures (sometimes derived from average daily air temperatures) were interpolated for the current condition.

There are differences in the general health of aquatic and riparian ecosystems between the east and west sides of the Cascade Mountains. Eastern areas are generally more sensitive and display the effects of past grazing, logging, road building, mining, and reduction in beaver populations. Westside hydrologic systems are most affected by roads, natural disturbance, and adjacent logging and dams. Though the current conditions on the westside are generally on the less desirable end of the range of natural variability, or in some cases outside the range, the overall effects do not appear as severe as on the eastside.

A primary concern from the Blue Mountain and Ochoco National Forest assessments is water quality. Several streams in those areas exceed Oregon state temperature water quality standards. Central Oregon forests generally exhibit a greater departure from historic to current maximum stream temperatures (Fig. 26). During low flow periods the temperatures are often too high to maintain sensitive fish species.

Percent of Stream Influence Zone in Early and Late Successional Stage

This measure is an index of the degree to which stream-adjacent vegetation provides effective shading of streams. Interestingly, in many cases the early successional riparian vegetation was within the range of natural variability or above, suggesting that natural disturbances of fire, insect, and drought contributed to many or more streamside openings historically. In contrast, adjacent late successional riparian vegetation is often less than the historic estimates, generally having a net negative effect on shading and large woody debris recruitment.

The ranges of natural variability for this element were determined from historic natural disturbance regimes and the resulting riparian vegetative condition. Early and late successional stage terrestrial information was factored into estimated streamside conditions by river basin. Current percent of stream influence zone in early successional state estimates also relied upon terrestrial data, and additionally considered the area currently occupied by roads.

Percent of Bare Ground within Stream Influence Area

This measure displays the effects of domestic and natural grazing on eastside forest streams. Riparian vegetation is critical to eastern Oregon and Washington ecosystems. Natural riparian vegetation is composed of coniferous and deciduous species, a mixture of trees and shrubs, or just shrub communities. This vegetation contributes to stream shade, is a positive indicator of hyporheic (lateral movement) zones, and provides bank stability. Assessment results indicate that a number of river basins are outside of sustainable ranges for this element. Corrective management practices have increased riparian vegetation in degraded eastside streams, but the time necessary to truly restore hydrologic function is long and greater efforts are needed.

The ranges of natural variability for percent of bare ground within stream influence zone were determined from historic natural disturbance regimes. It was assumed that bare ground conditions in riparian and stream influence zones were few, that is, most of the area would have been vegetated or stablized. Current condition information was gathered from recent inventories and reports from forest range programs.

In conclusion, we have gained a "first approximation" of the condition of the Pacific Northwest Region's aquatic and riparian ecology. There is an overall simplification of streams that reduces fish habitat. The aquatic and riparian systems in eastern Oregon and Washington are generally more sensitive to change and display a number of serious problems. Major concerns in eastern Oregon are water quality and the health of riparian vegetation and stream simplification. Finer scale ecological assessment is needed to identify corrective management. A primary focus should be to prevent further damage in those streams currently within sustainable ranges. Restoration projects should be identified, prioritized, and funded for those streams far outside sustainable limits.

Figure 20. Historic range, current range, and current mode of river basin pool frequency in intermediate tributary streams west of the Cascade Mountains in Washington. Basins which had limited data are shown by (*).

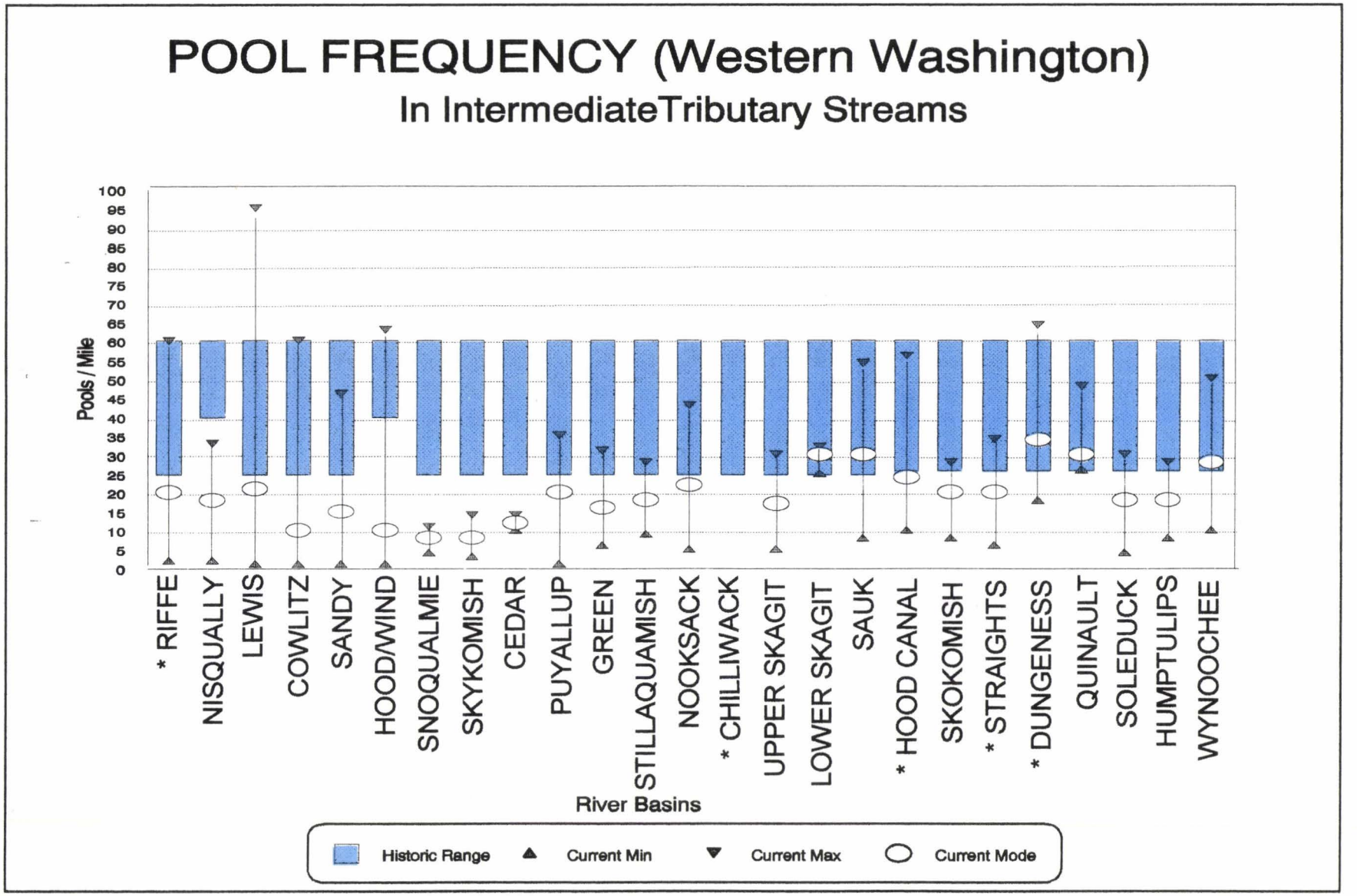


Figure 21. Historic range, current range, and current mode of river basin pool frequency in intermediate tributary streams west of the Cascade Mountains in Oregon. Basins which had limited data are shown by (*).

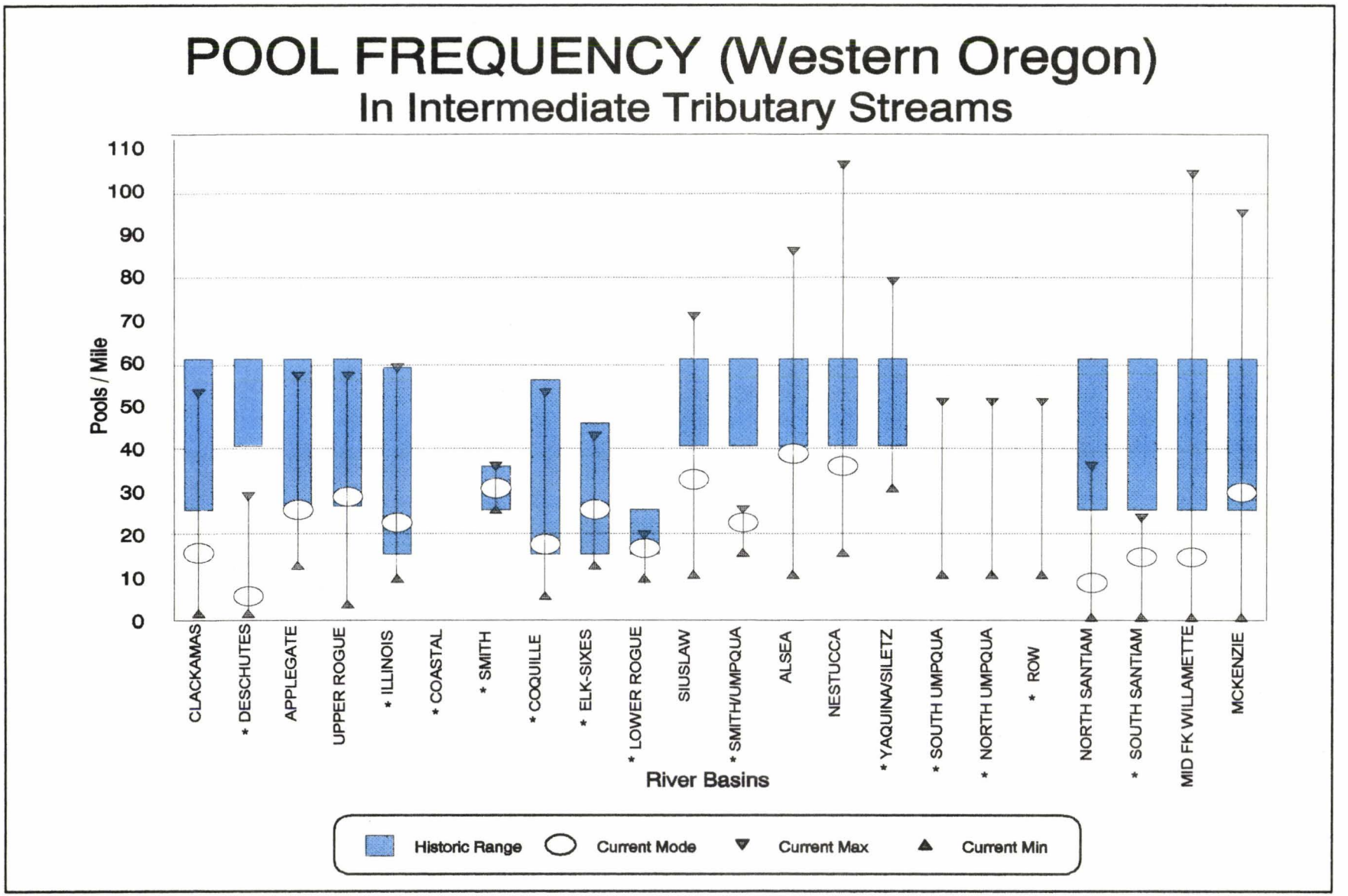


Figure 22. Historic range, current range, and current mode of river basin pool frequency in intermediate tributary streams of central Oregon. Basins which had limited data are shown by (*).

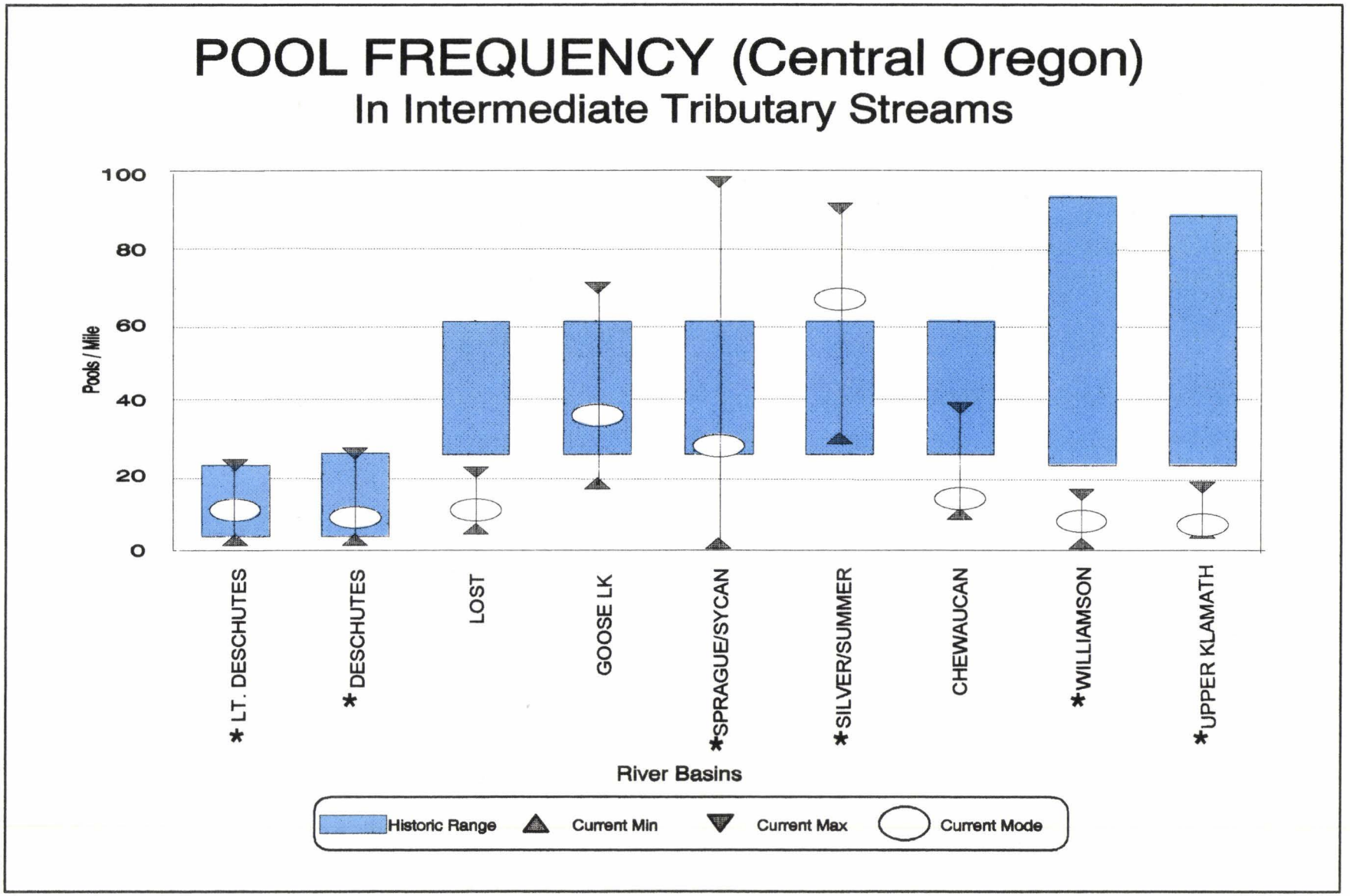


Figure 23. Historic range, current range and current mode of maximum water temperature for intermediate tributary streams west of the Cascade Mountains in Washington. Basins which had limited data are shown by (*).

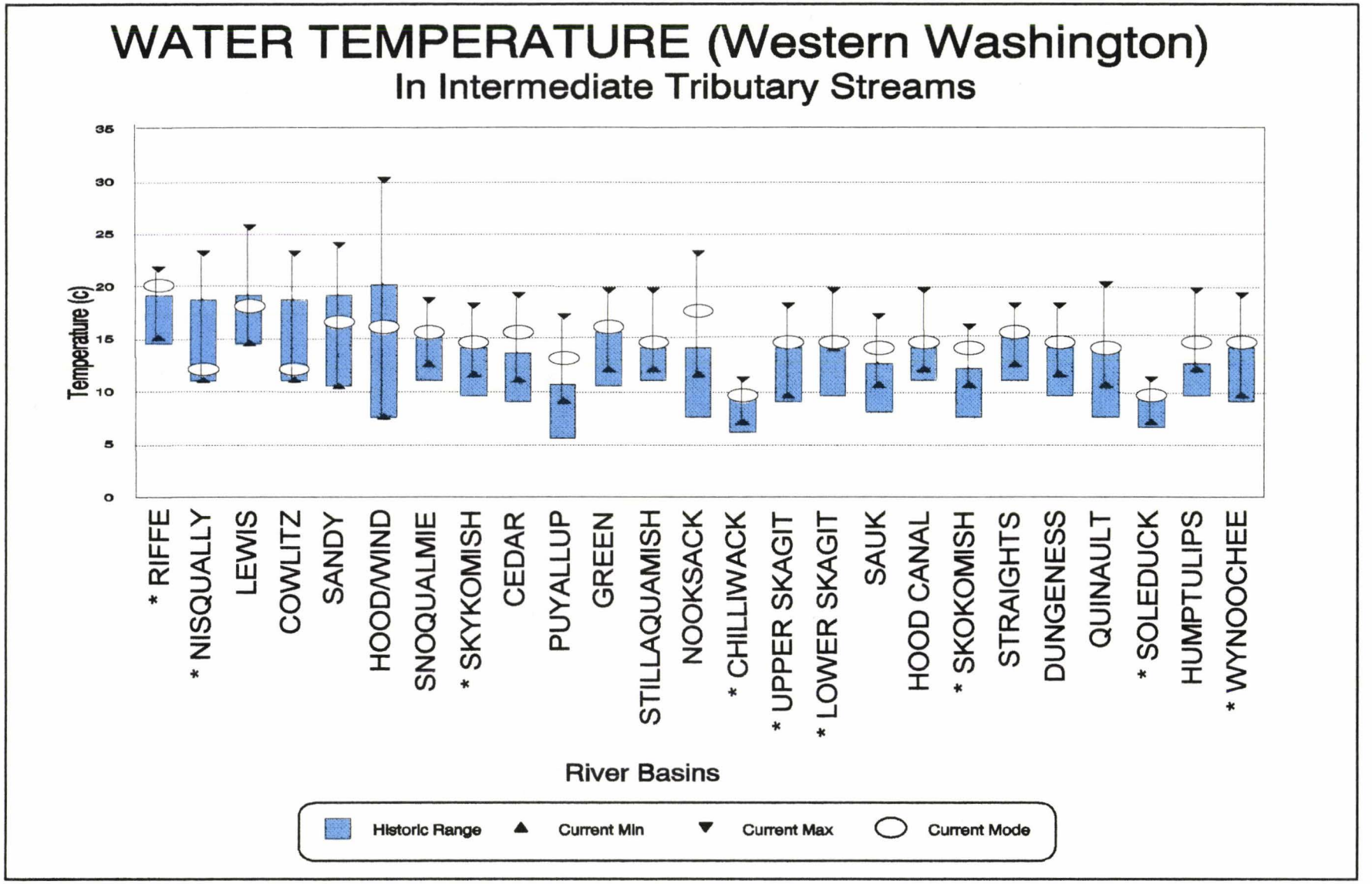


Figure 24. Historic range, current range, and current mode of maximum water temperature for intermediate tributary streams east of the Cascade Mountains in Washington. Basins which had limited data are shown by (*).

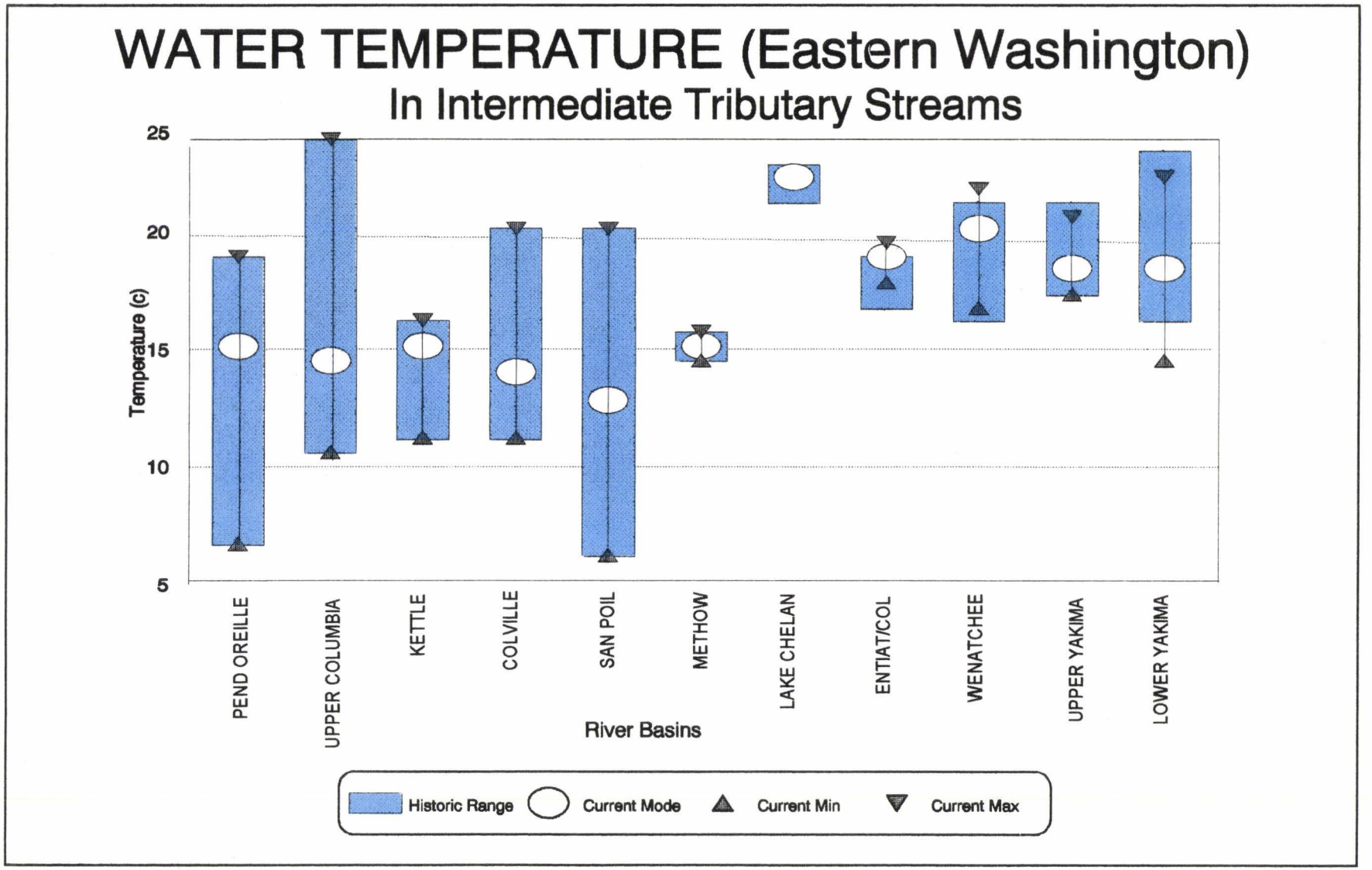


Figure 25. Historic range, current range, and current mode of maximum stream temperature for intermediate tributary streams west of the Cascade Mountains in Oregon.
Basins which had limited data are show by (*).

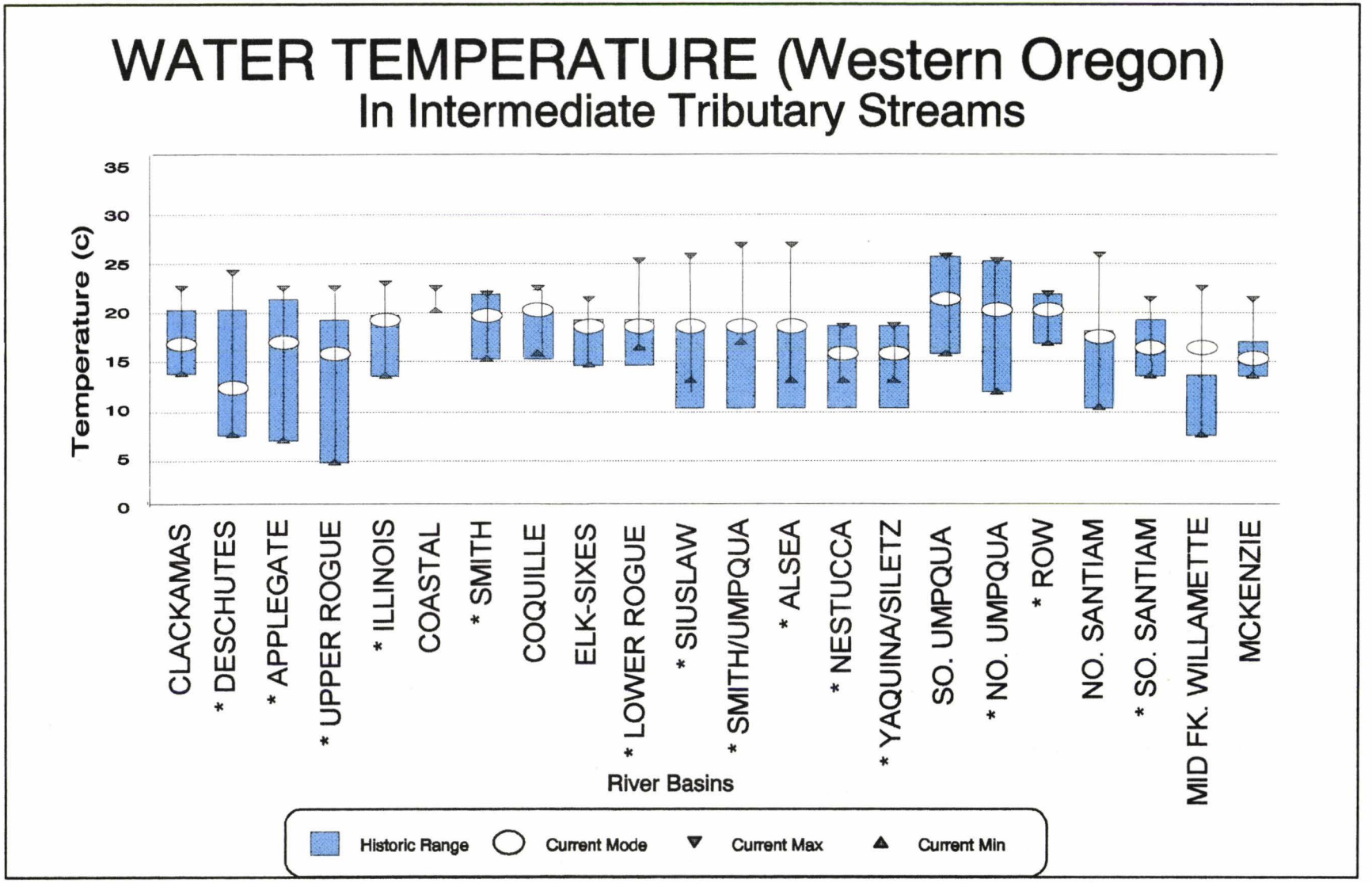
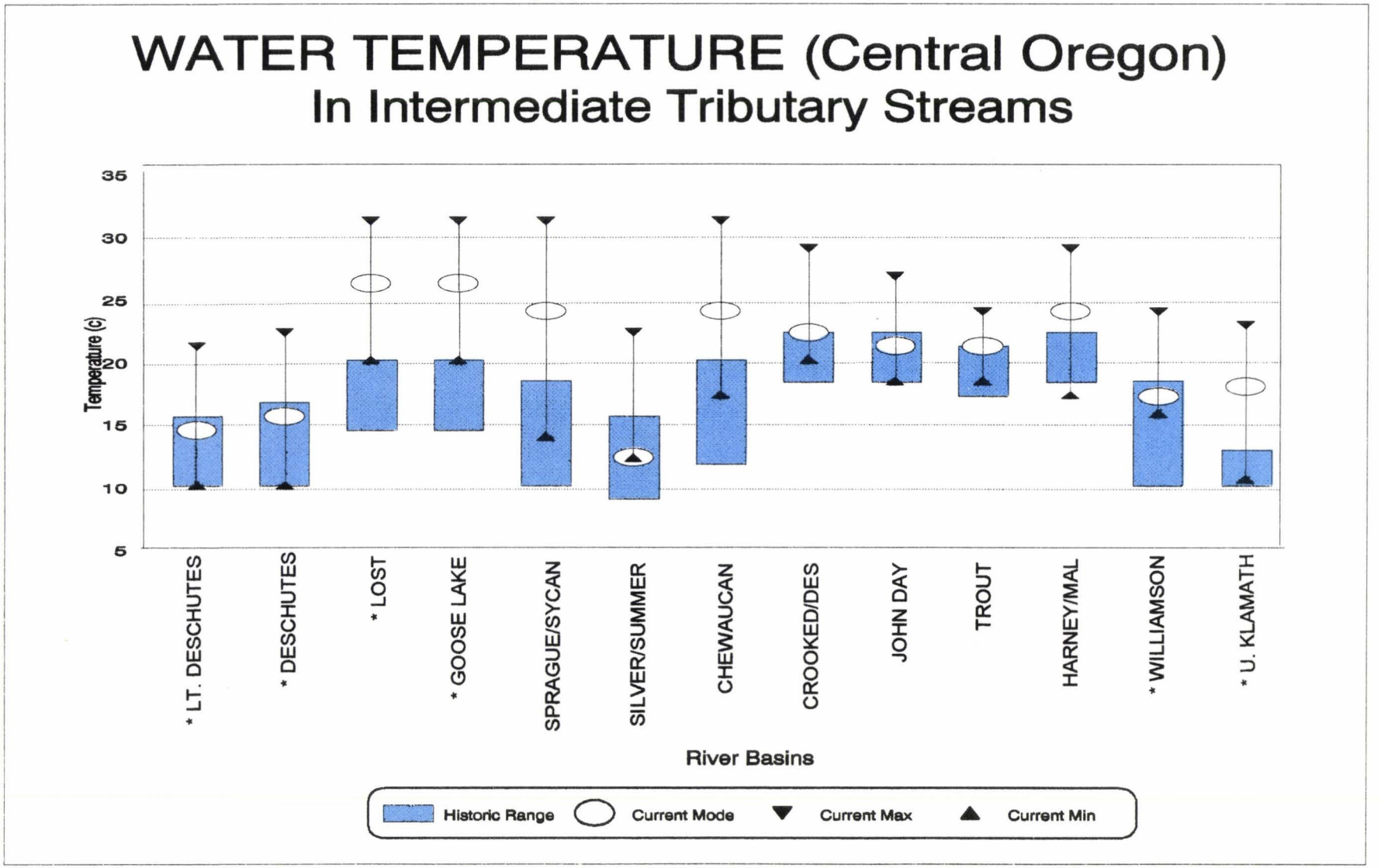


Figure 26. Historic range, current range, and current mode of maximum stream temperature for intermediate tributary streams in central Oregon (Deschutes, Ochoco, Winema, and Fremont National Forests). Basins which had limited data are shown by (*).



Regional Atmospheric Ecosystem Results

Air quality is a major environmental issue in the States of Oregon and Washington. It affects quality of life for people residing in the Pacific Northwest, and the quality of visitor experiences. Air quality also affects biotic ecosystem health. An atmospheric assessment compared current air quality in Oregon and Washington to the past.

The role of fire in the landscape affects resulting smoke emissions. Air quality is influenced by fire frequency and severity, area burned, fuelbed conditions, fire seasonality, weather and drought trends. Many of these elements have changed in the last 100 years. Today wildfires are actively suppressed, and prescribed fire use is controlled by state and federal regulatory agencies.

Prescribed burning is a management tool that can be used to reduce fire hazard. In some situations it can create air quality conditions through smoke emissions that are socially undesirable. Unabated fire hazards can result in catastrophic wildfires, which ultimately create large volumes of smoke. Fire management specialists suggest that fuel reduction programs including prescribed fire can reduce total smoke emissions.

The primary focus of the atmospheric assessment was to compare smoke emissions from presettlement times to current smoke emissions. Figures 27 and 28 display the results of that comparison by emissions and by acres. In all cases, historic estimates exceed current estimates.

Particulate matter less than 10 microns in diameter (PM10) was selected to characterize smoke emissions from forest fires. National air quality standards have been established for PM10 because it is small enough to be respirable and can impact human health. Also, much of PM10 is small enough to remain airborne for days and cause visbility impacts.

For this assessment, the Pacific Northwest Region was divided into six areas based on similar fuel types and fire frequencies. They are:

- **Eastern Oregon** (Deschutes, Fremont, Malheur, Ochoco, Umatilla, Wallowa-Whitman, and Winema),
- **Western Oregon** (Mt. Hood, Columbia River Gorge National Scenic Area, Siuslaw, Willamette),
- **Southwest Oregon** (Rogue River, Siskiyou, Umpqua),
- **Olympic Penninsula** (Olympic),
- **Western Washington** (Gifford Pinchot, Mt. Baker-Snoqualmie), and
- **Eastern Washington** (Okanogan, Wenatchee, and Colville).

Fuel models from the National Fire Danger Rating System (The National Fire Danger Rating System, Deeming and others, General Technical Report INT-39, 1978) were used to assign fuel loadings for areas burned during historic and current time periods. NFDRS fuel model assignments for historic wildfires were based upon County timber type and timber volume estimates published in 1902 (Forests of Oregon, and Forests of Washington, Henry Gannett, US Geologic Survey, 1902).

The results show that PM10 smoke emissions from Forest Service lands are lower now than they were historically (Figure 27) in all geographical areas. Comparison of acres burned annually (Figure 28) shows that in most areas the drop in emissions is due to a large drop in acres burned per year.

Average annual acreage and emission estimates were derived from wildfire occurrence records 1986-1990 and prescribed burn inventories from 1991 and 1992. Wildfire occurrence was disproportionately high in Eastern Oregon during the time period 1986-1990. Forest health degradation and drought have been identified as the primary causal agents. In figures 27 and 28 current conditions represent a much higher fraction of the estimated historic conditions in Eastern Oregon than in Eastern Washington. Historically, fire return intervals and fuel conditions in these fire-adapted ecosystems were roughly similar.

Smoke emissions per acre in Eastern Oregon and (to a lessor extent) Eastern Washington are increased from historic levels because of higher current fuel concentrations. The authors of Forest Health in the Blue Mountains: A Management Strategy for Fire-Adapted Ecosystems, (Mutch and others, General Technical Report PNW-310, 1993) maintain that fire exclusion and selective logging have greatly increased fuel loadings in Eastern Oregon. They suggest further "the ecological deterioration evident in the Blue Mountains has disturbing implications for similar forest types at other locations."

Southwest Oregon and Western Oregon show similar fire acreage and smoke emission comparisons. Western Washington and the Olympic Penninsula have the least acres burned historically and currently, which equate to the least emissions generated. It is difficult to portray the smoke emission situation on the Olympic Forest using an annual average analysis when historic fire return intervals exceed 300 years.

Estimates of emissions are for Forest Service lands only. These values should not be considered representative of current or historic smoke emissions throughout the States of Washington and Oregon. A similar process could easily be adapted to cover other lands.

Figure 27. Average annual results of atmospheric assessment. PM10 emissions from prescribed fires and wildfires.

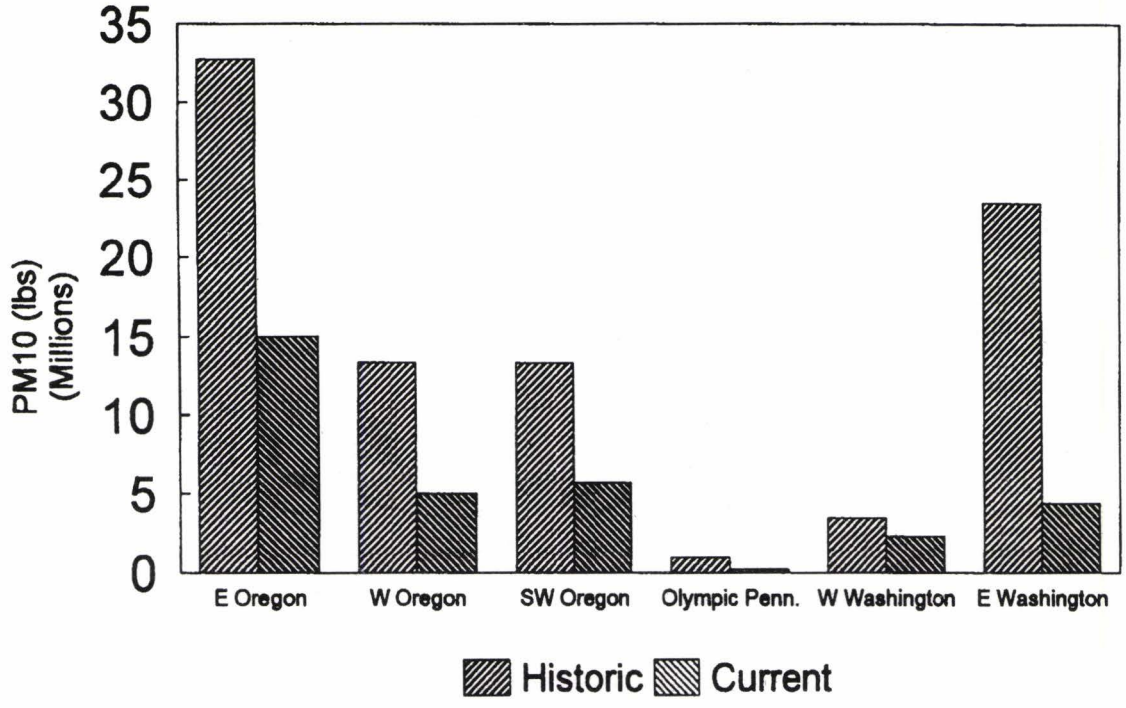
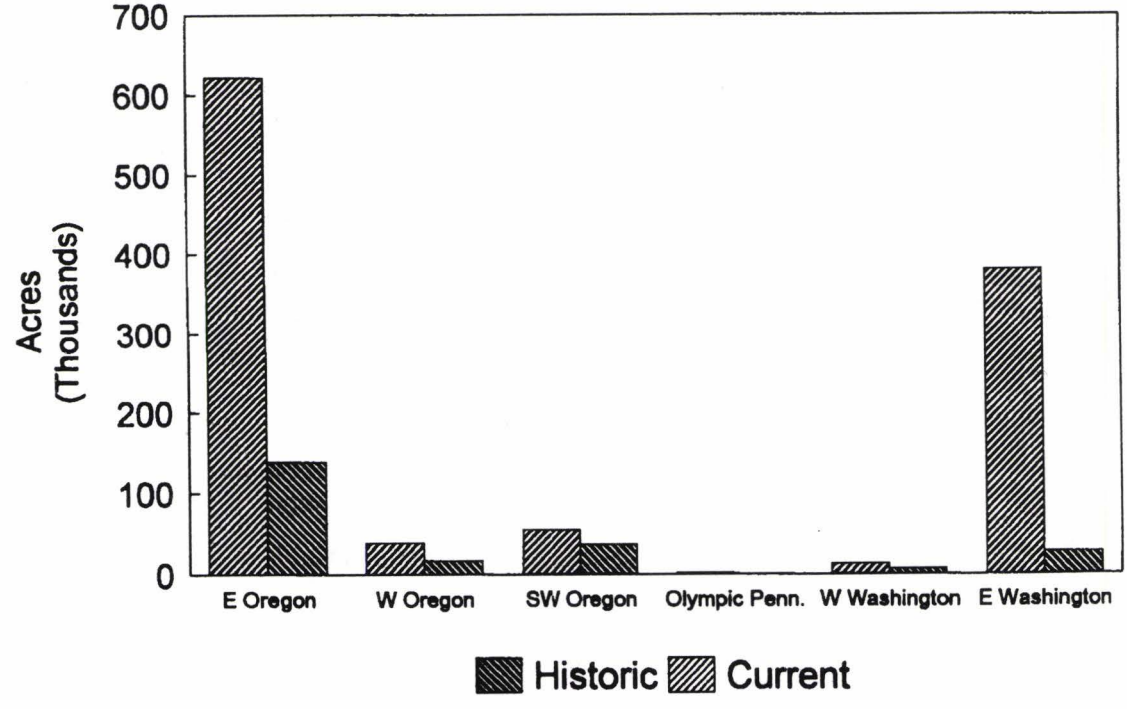


Figure 28. Average annual results of atmospheric assessment. Acres from prescribed fires and wildfires.



Assessment Contributors

Regional Team

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Ecosystem Management Specialist:	Diane White (Major Contributor to Regional Summaries)
Partners and Review Coordinator:	Tom Beddow
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Iral Ragenovich	Larry Cronenwett	Dave Heller	Sarah Crim
Bruce Marcot	Robert Muerisse	Susan Sater	Gail Saunders-Boyle

Subregional teams submitted summaries for inclusion in this regional assessment report. The teams are listed below and the summaries are included in the following pages.

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Wallowa-Whitman, Umatilla, Malheur and Ochoco

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Deschutes, Fremont and Winema

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	Larry Cooper
	Tim Sexton
	Joy Augustine
	Scott Beyer
Ecologist:	Matt Busse (Team Leader Terrestrial Forested)
	Jay Dunbar
	Sue Puddy
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Hydrologist:	Deigh Bates
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Regional Geneticist	Sheila Martinson

Subregional Summaries

West Central Washington: The Olympic and Mt. Baker-Snoqualmie National Forests

Fire and wind are the two disturbance regimes that operate on the Olympic and Mt. Baker-Snoqualmie National Forests. In fire-prone rainshadows, especially at lower elevations, stand-replacement fires have occurred every 200 to 300 years. Windward areas and higher elevations burn rarely, if at all. Wind is a more important disturbance factor in these areas. Wind disturbance was not evaluated in the analysis.

Fires burned much of the east, northeast, and north portions of the Olympic National Forest during large burning periods in about 1308, 1508, and 1701. Within the Mt. Baker-Snoqualmie National Forest most major river valleys north of the South Fork Snoqualmie River burned and most of the area to the south burned also. The large range of the natural variability over the 300 year analysis period is a result of large areas burning and maturing to late successional stages before burning again. More of the western hemlock zone burned than the silver fir zone. The mountain hemlock zone burned the least. The silver fir and mountain hemlock zones recover more slowly and remain in an early successional condition longer than lower elevation zones. At the turn of the century there was as much or more late successional, single layer forest than at any time in the past 300 years. Currently most areas within the burn perimeters of old fires have about as much or less late successional forest as occurred after each large fire. Much of the remaining late successional single layer forest is now in transition to a multilayered condition.

In some of the driest areas smaller fires occur more frequently. Burning and reburning at short intervals can produce an early successional condition with few snags or logs. These areas are most likely to be found in the Dungeness, Puyallup and Green River basins.

Large areas of the less fire-prone forests existed as late multilayered stands throughout the analysis period and probably for much longer. A very high level of stability over the long term has been the dominant pattern in these areas. In modern times most of these areas experienced greater reductions of late successional forest than at any time in the past. In the Olympic National Forest these areas are at high elevations or on the windward side of the Olympic Peninsula. The entire Humptulips basin appears to be devoid of fire activity and uninterrupted succession may have proceeded for over 1,000 years. On the Mt. Baker-Snoqualmie National Forest old, stable areas are found at higher elevations or in wetter portions of the Chilliwack, Lower Skagit, Stilliguamish, Skykomish and Snoqualmie basins.

Considerable conversion of late successional to early and mid-successional stages of forest occurred during this century in non-reserved areas. Conversion is mostly the result of patch harvest activity, but fires have been locally important. In areas affected by the large historic fires the amount of early and mid-successional forest is not large compared to historic forests. Most of the modern, early successional forests and mid-successional forests derived from harvest activities lack snags and logs and are not equivalent to the early and mid-successional forests which occurred in the past.

The scattering of patch openings through the remaining late successional forest has resulted in greater fragmentation than occurred in the past. Much of the remaining late successional forest is not equivalent to late successional forests of the past due to higher levels of fragmentation.

The analysis shows a higher percent of riparian forests in late successional stages than terrestrial forests. This is expected since riparian areas are moist and less prone to burning.

River basins heavily impacted by the large historic burning periods are generally within the range of historic condition for disturbance. After wildfire, large amounts of erosion and sedimentation occurred in the following 10 to 30 years, followed by hundreds of years of recovery until the next stand-consuming wildfire. In many instances, mosaics of unburned or partially burned stands were left in riparian areas and along ridges. Present river basin disturbances are represented by a different spatial and temporal pattern of roads and openings, creating chronic pulses of sediment throughout the last 50 to 70 years with very little recovery period. Roads have also altered hillslope hydrology and contributed to slope stability problems.

River basins with a low incidence of wildfire are generally outside the historic range of variability for disturbance. In these areas stand disturbance resulted from windfall. Natural patterns of disturbance were small in extent and with frequencies averaging every ten years. Present disturbance patterns are larger in extent spatially but may emulate natural rates of disturbance temporally.

Soil loss due to accelerated erosion has increased bedrock outcrop and decreased soil depth. This factor, added to high road densities in some watersheds, induces hydrologic and sediment effects to the aquatic environment that are not indicated by this analysis. Historically, peak sediment rates were tied to wildfire and windfall events. Effects of wildfires and catastrophic sedimentation events every 10 to 500 years, disturbing 20 to 60 percent of the basin are far different than harvest and road entry into a watershed every 5 to 10 years, typically disturbing 25 percent of the watershed with each entry. The ability of a watershed for recovery is related to time between events. The natural range of variability of mass wasting is a critical element in understanding how rates of sediment pulses may have changed from the natural to managed condition. The rate of sediment pulsing from tributary streams has also been dramatically changed by management activities that reduced or eliminated large woody materials from channels. These materials temporarily retain large volumes of sediment.

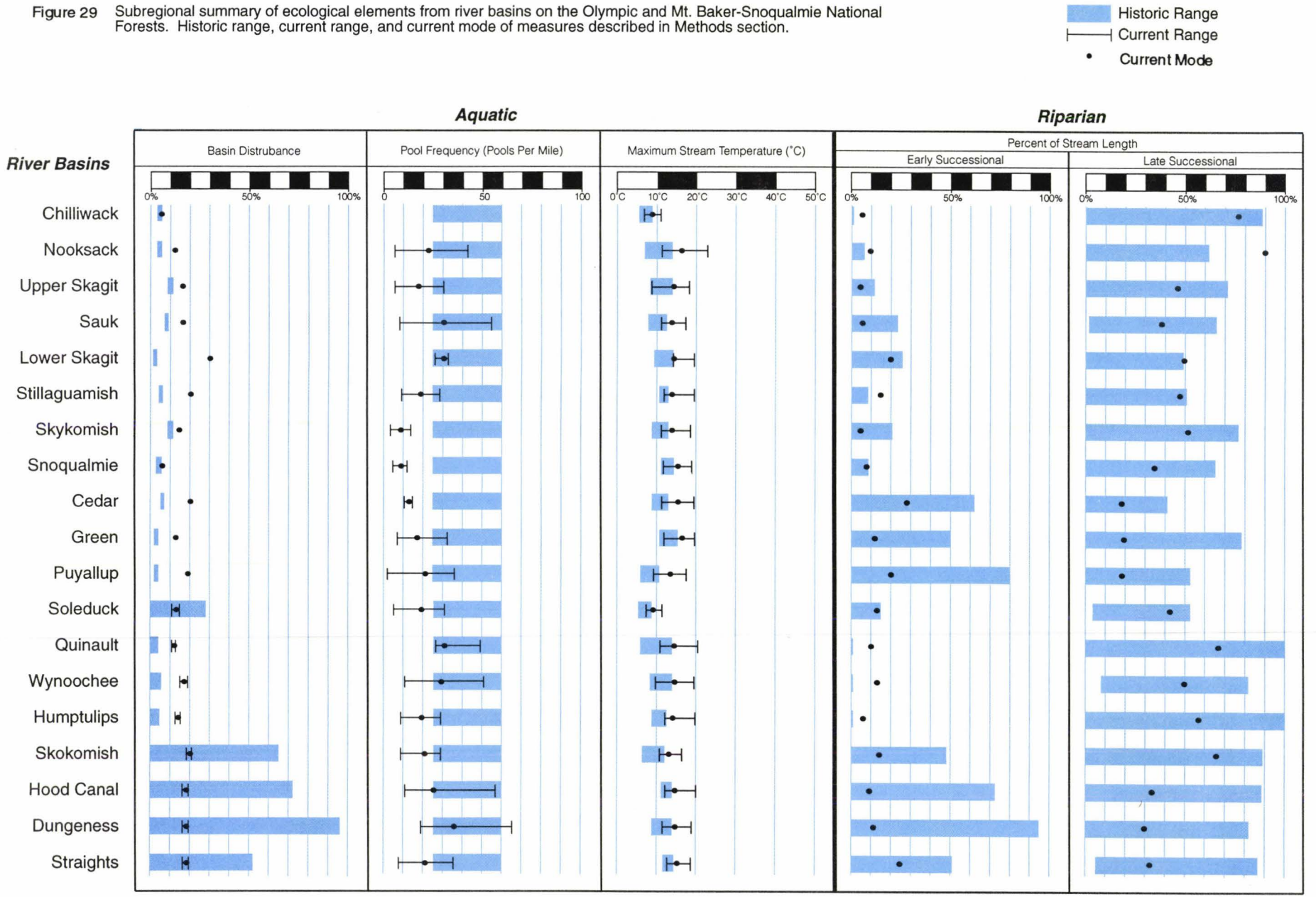
Generally, specialists believe higher levels of sedimentation associated with harvest activities and roading have contributed to loss and partial filling of river pools. The loss of large pools is most likely the result of the loss of pool forming agents such as large, stable woody debris and the effect of increased bedload from mass-wasting and debris torrents. Recent and historical flood events are also a factor.

In general, stream temperatures have probably increased. In some streams meltwater from the glaciers probably holds maximum temperature within a range compatible with the fisheries resource, but stream temperatures have undoubtedly increased over historical temperature regimes. Increases are due to widening of stream channels and loss or modification of riparian vegetation that allows greater insulation. Another factor is the general decrease in pool frequency and depth. At low summer flows the deeper pools within most stream systems will thermally stratify (a layer of warm water over the denser, cooler water that fills most of the pool volume).

Where the range of conditions has been large due to intense fire history, most elements fall within the historic range. Temporal and spatial aspects must be considered to interpret these results. In areas with little fire history, most elements fall outside the range of historical variability. In most areas late successional multilayered forests are now below the historical range, regardless of fire regime. Single layered, late successional forests which represent recruitment potential for multilayered late successional forests are often at the lower end of the range of natural condition.

Data are illustrated in Figure 29.

Figure 29 Subregional summary of ecological elements from river basins on the Olympic and Mt. Baker-Snoqualmie National Forests. Historic range, current range, and current mode of measures described in Methods section.



Subregional summary of ecological elements from river basins on the Olympic and Mt. Baker-Snoqualmie National Forests. Historic range, current range, and current mode of measures described in Methods section.

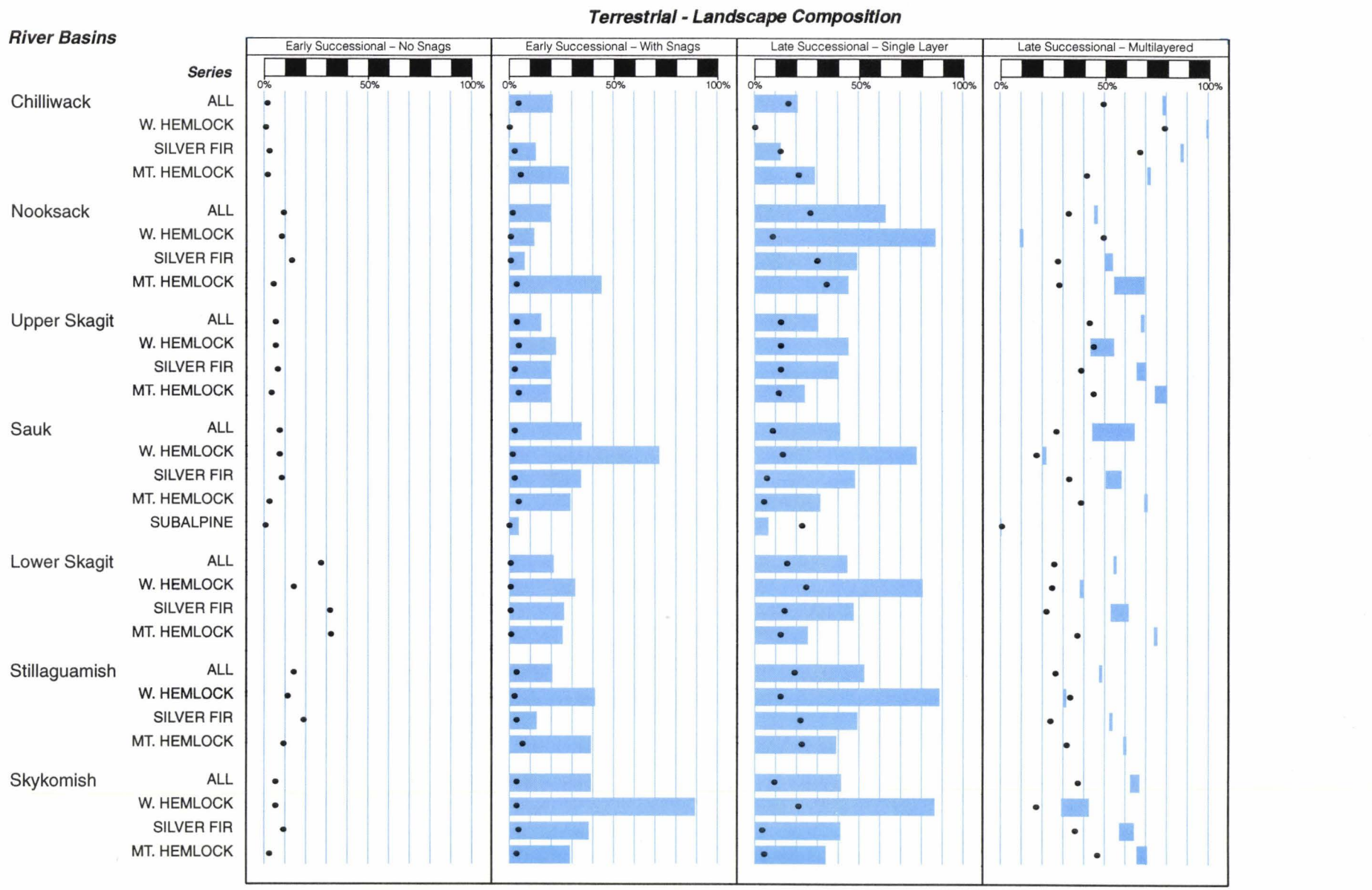
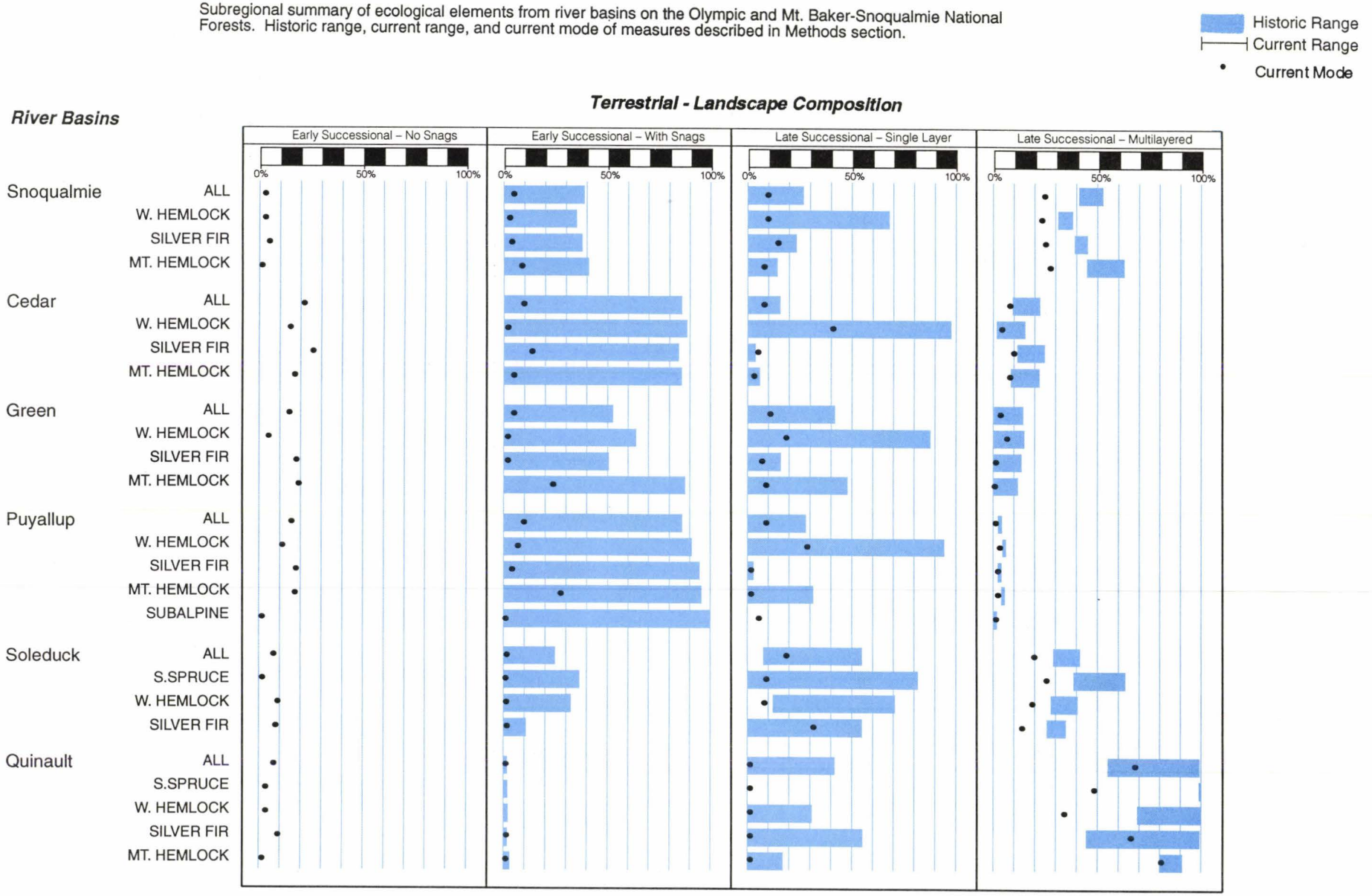
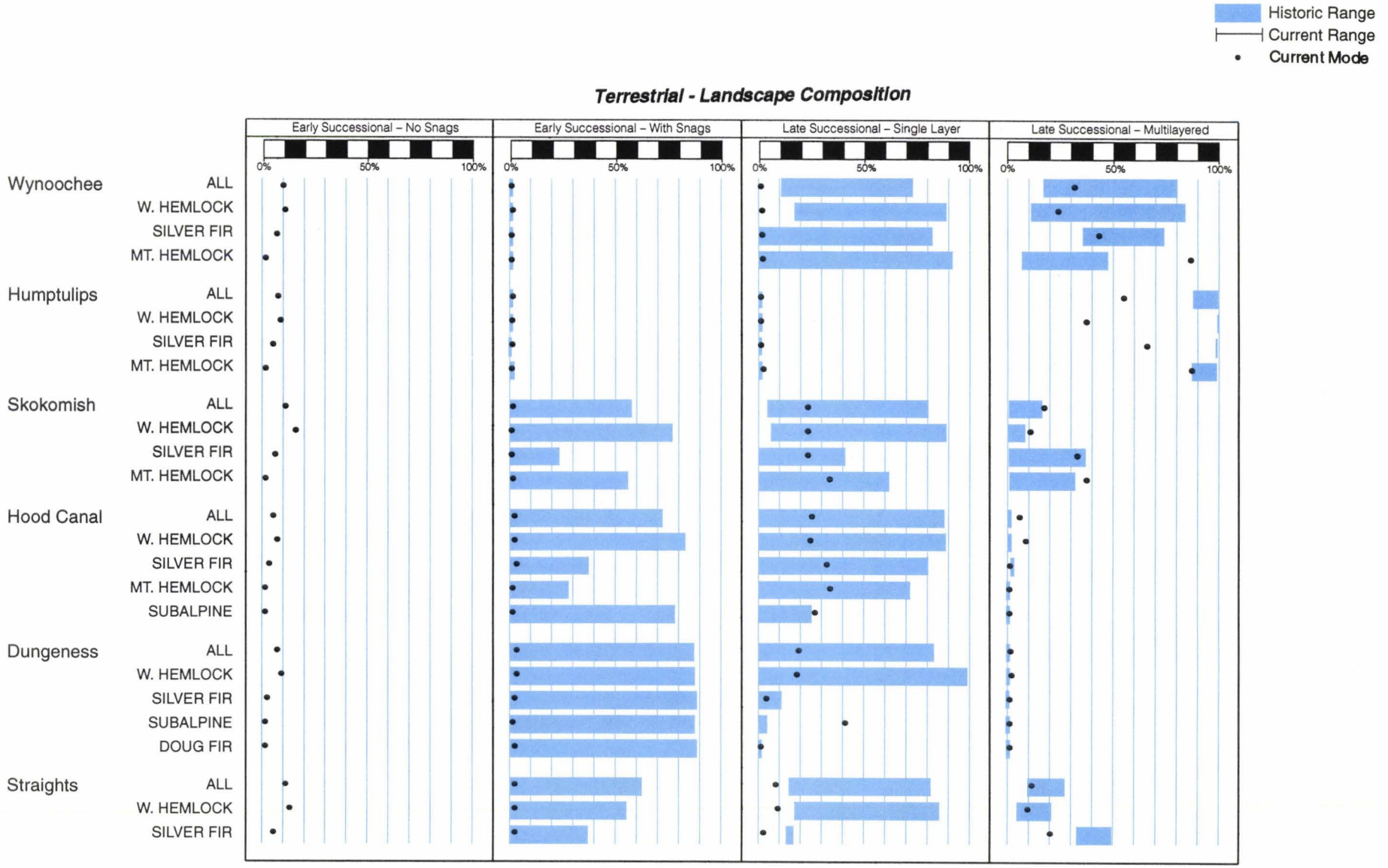


Figure 29 page 3 of 4

Subregional summary of ecological elements from river basins on the Olympic and Mt. Baker-Snoqualmie National Forests. Historic range, current range, and current mode of measures described in Methods section.




Historic Range
Current Range
Current Mode
Terrestrial - Landscape Composition
Early Successional – No Snags
Early Successional – With Snags
Late Successional – Single Layer
Late Successional – Multilayered
0%
50%
100%
Wynoochee
ALL
W. HEMLOCK
SILVER FIR
MT. HEMLOCK
Humptulips
ALL
W. HEMLOCK
SILVER FIR
MT. HEMLOCK
Skokomish
ALL
W. HEMLOCK
SILVER FIR
MT. HEMLOCK
Hood Canal
ALL
W. HEMLOCK
SILVER FIR
MT. HEMLOCK
SUBALPINE
Dungeness
ALL
W. HEMLOCK
SILVER FIR
SUBALPINE
DOUG FIR
Straights
ALL
W. HEMLOCK
SILVER FIR

Eastern Oregon: The Wallowa-Whitman, Umatilla, Malheur and Ochoco National Forests

The forested ecosystems of the Blue Mountains in northeastern Oregon are complex and highly variable. The complexity comes from the multitude of interactions between the land, the climate, the water, and the vegetation. Natural disturbance regimes are dominated by fire. Fires are generally quite frequent and of low intensity, although stand-replacement events do occur. Fire regime varies by vegetation zone and has contributed to the structure of the vegetation.

Throughout the Blue Mountains, the amount of climax fir forest dominated by pine and larch is currently less than the estimated ranges of natural variability, especially in the driest, southern portion of the Blue Mountains.

Progressing southward through the Blue Mountains, the amount of climax fir forest composed of multiple layers of Douglas-fir and true fir increases to levels that are now higher than the estimated range of natural variability.

Some of the river basins in the southern Blue Mountains have significantly higher percentages of high density, low vigor ponderosa and lodgepole pine than under "natural" conditions.

Almost all the river basins currently show higher levels of available fuels than natural. Available fuels are defined by the Caraher team as standing dead and down material expressed as a percent of the total biomass on site. It is intended to show the relative relationship of fire hazard and potential fire intensity.

Riparian shrub cover and streambank stability are below their ranges of natural variability in most of the river basins in the Blue Mountains, especially in the central and southerly portions.

Conditions within the river basins can be grouped into three broad categories:

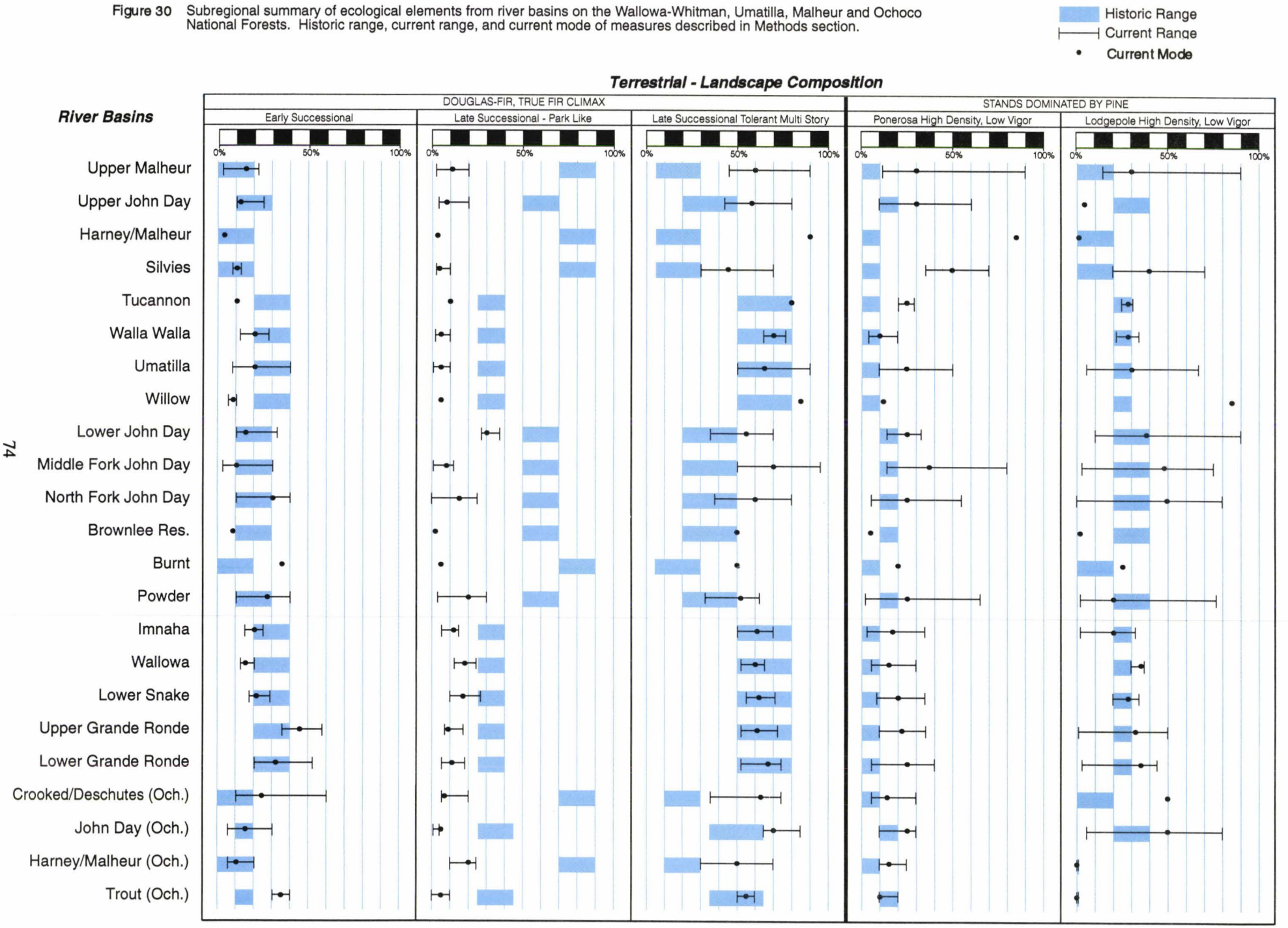
- river basins which are currently far outside naturally sustainable ranges;
- basins which are outside sustainable levels and are tending toward greater ecosystem imbalance; and
- basins which are near or within naturally sustainable ranges.

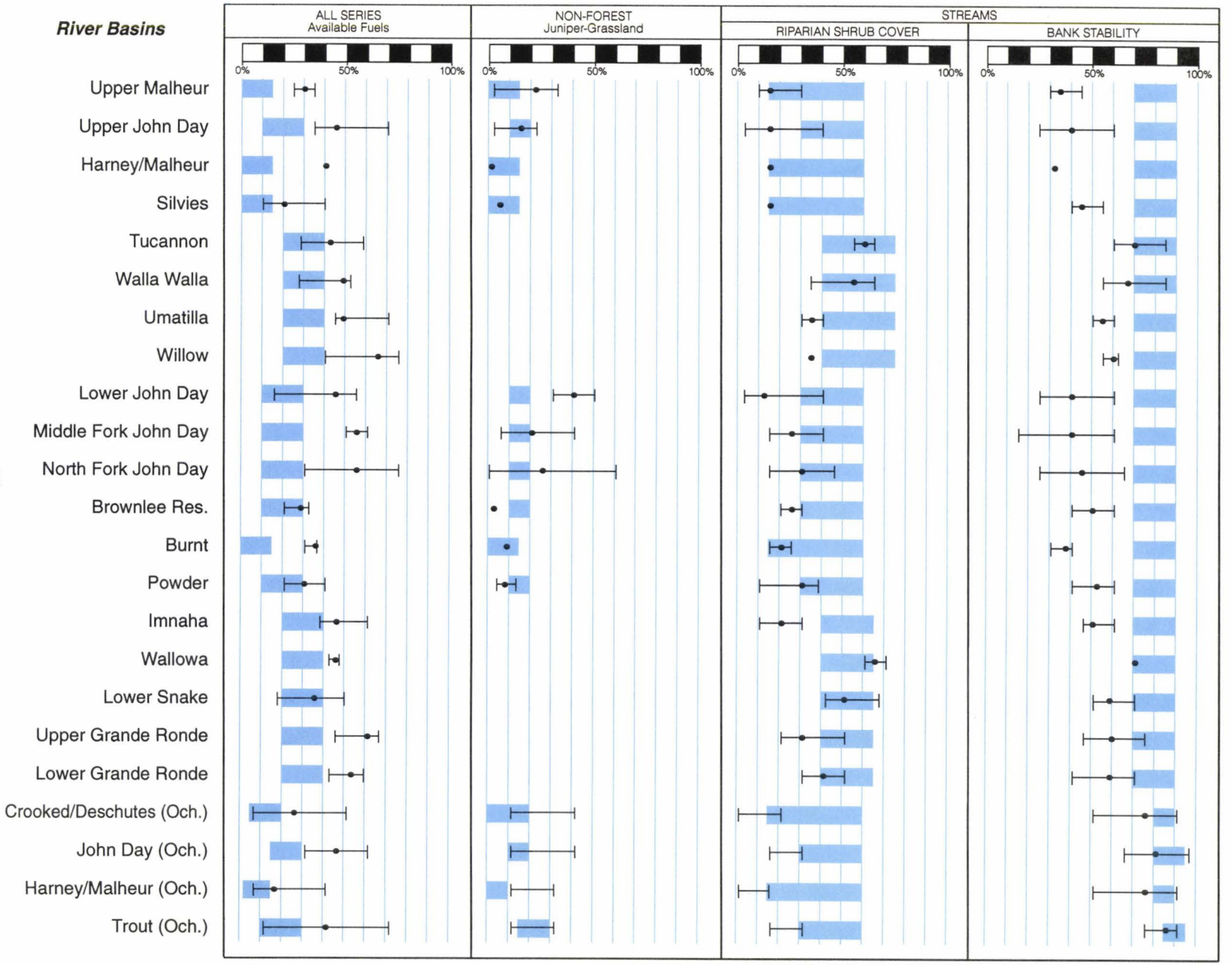
A panel of Forest Service resource specialists conducted an assessment of forest health in the Blue Mountains and found that five of nineteen river basins are "far outside," five are "outside," and nine are "close to or within" a naturally sustainable range of ecosystem health.

Basins far outside naturally sustainable ranges exhibit high fuel loadings, poor stand structure, and excessive streambank instability--characteristics which pose substantial risk to terrestrial and aquatic ecosystems. River basins that are currently outside sustainable levels have fuel loadings, stand structures, and streambank stabilities far enough away from natural ranges to be of concern. River basins that are near or within naturally sustainable ranges are considered healthy.

Data are illustrated in Figure 30.

Figure 30 Subregional summary of ecological elements from river basins on the Wallowa-Whitman, Umatilla, Malheur and Ochoco National Forests. Historic range, current range, and current mode of measures described in Methods section.




River Basins
ALL SERIES
Available Fuels
NON-FOREST
Juniper-Grassland
STREAMS
RIPARIAN SHRUB COVER
BANK STABILITY
0%
50%
100%
Upper Malheur
Upper John Day
Harney/Malheur
Silvies
Tucannon
Walla Walla
Umatilla
Willow
Lower John Day
Middle Fork John Day
North Fork John Day
Brownlee Res.
Burnt
Powder
Imnaha
Wallowa
Lower Snake
Upper Grande Ronde
Lower Grande Ronde
Crooked/Deschutes (Och.)
John Day (Och.)
Harney/Malheur (Och.)
Trout (Och.)

Central Oregon: The Deschutes, Fremont, and Winema National Forests

Ecosystems in central Oregon have several natural disturbance agents. In ponderosa pine and white fir series, fire played an important role in shaping stand structure by frequent, light underburns. This resulted in low density, open, park-like stands of pioneer conifers, either ponderosa pine or Douglas-fir, depending on climate. In lodgepole pine areas, the species has a shorter life span--up to 120 years. After that time, mortality sets in and fuels build up resulting in high intensity, stand-replacement fires. Insects and diseases such as root rots also play an important role. In naturally functioning ecosystems these agents interact with each other and population levels rise and fall. Large scale, catastrophic events occur, but not often.

It is apparent that past grazing, logging, and road building activities have had a major adverse impact on aquatic systems. These effects have changed the range of natural variability the most within the southern basins and the least within the Silver Creek and Summer Lake, Little Deschutes River, and Deschutes River basins. Activities have had significant effects on cold water ecosystems. Temperatures, for example, are much too high during low flow periods to sustain species such as bull trout and red band trout. The Goose Lake basin has five species which could be listed as threatened and endangered species by the U.S. Fish and Wildlife Service. A major effort is needed to restore these basins.

Riparian ecosystem function is negatively altered in most basins. Though current vegetation may reflect corrective management attempts, most sites are far from potential riparian vegetation and restored hydrologic function. Consumptive use of riparian ecosystems for the production of livestock and timber, as well as channel alteration, road building, dams, and fire exclusion have all caused negative impacts.

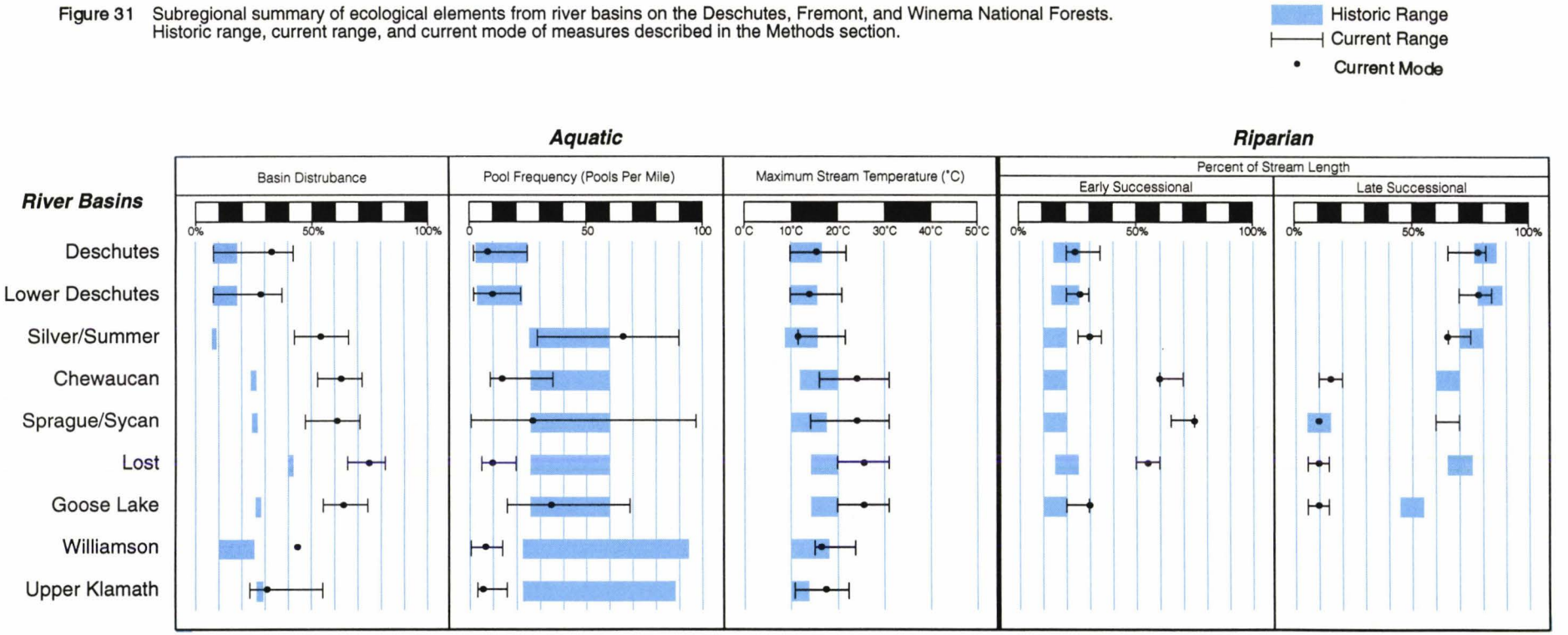
Conclusions for the forested ecosystems are fairly well recognized for central Oregon forests: fire suppression and selective harvesting have dramatically altered forest composition, structure, and processes. The competitive advantages of fir species following the removal of frequent, low intensity fires has resulted in reduced acres of ponderosa pine dominated forest. Also, a large discrepancy exists in many basins between the historic and current range of late successional, single layer pine stands. This can be attributed primarily to the extensive harvest activity in the 1920-30's, in addition to a severe mountain pine beetle outbreak during the past decade. On the positive side, active precommercial and commercial thinning operations in all basins, with the exception of the Upper Klamath Lakes, have reduced the quantity of dense, low vigor pine stands.

Control of wildfires has had a profound effect on non-forest ecosystems. Combined with aging shrubs, juniper expansion, and grazing, many of these ecosystems are in poor ecological and forage condition.

Eastside ecosystems do not have the resiliency associated with the westside ecosystems. Therefore, although we believe that management of these systems is appropriate given society's expectations and the dynamic nature of these systems, we also need to increase efforts to restore and rehabilitate many of the ecosystems and focus on management and future conditions that promote ecological sustainability.

Data are illustrated in Figure 31.

Figure 31 Subregional summary of ecological elements from river basins on the Deschutes, Fremont, and Winema National Forests. Historic range, current range, and current mode of measures described in the Methods section.



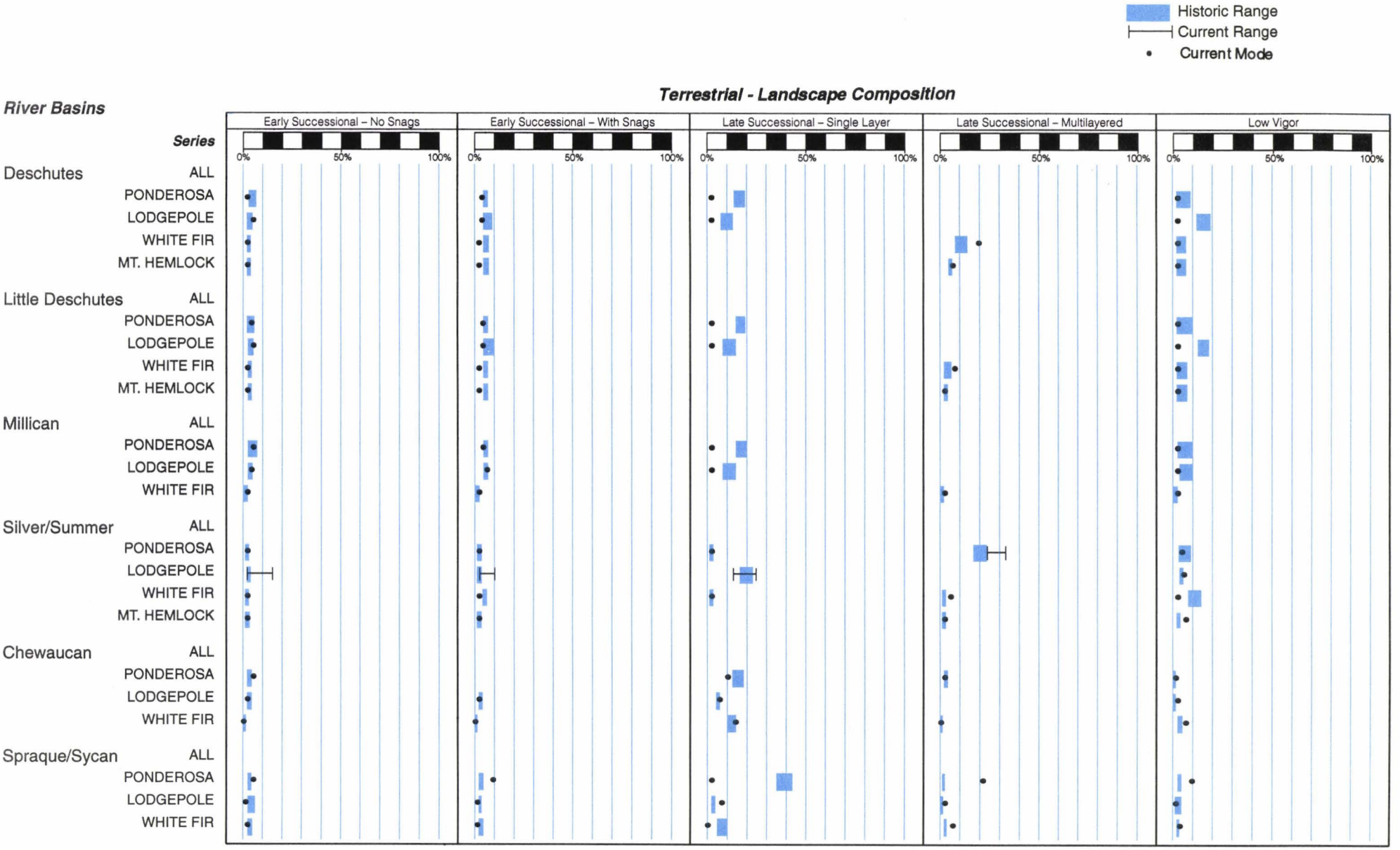
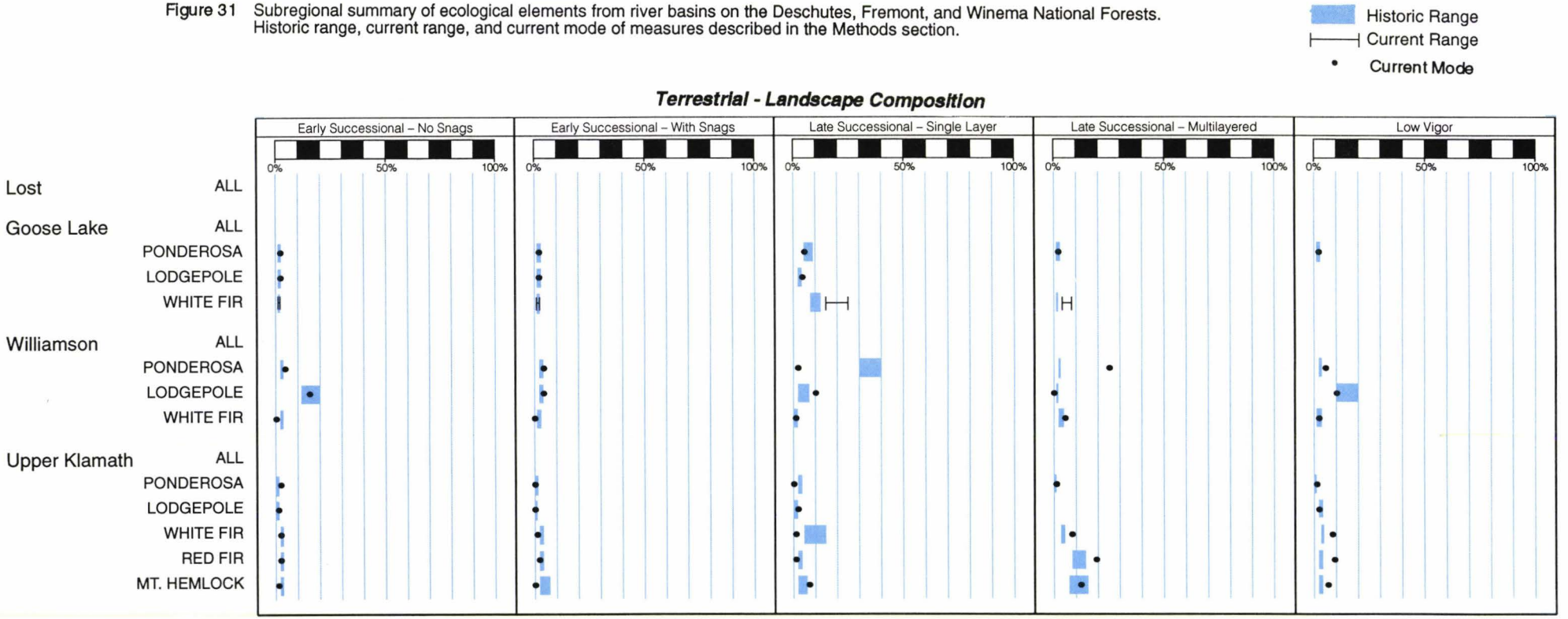
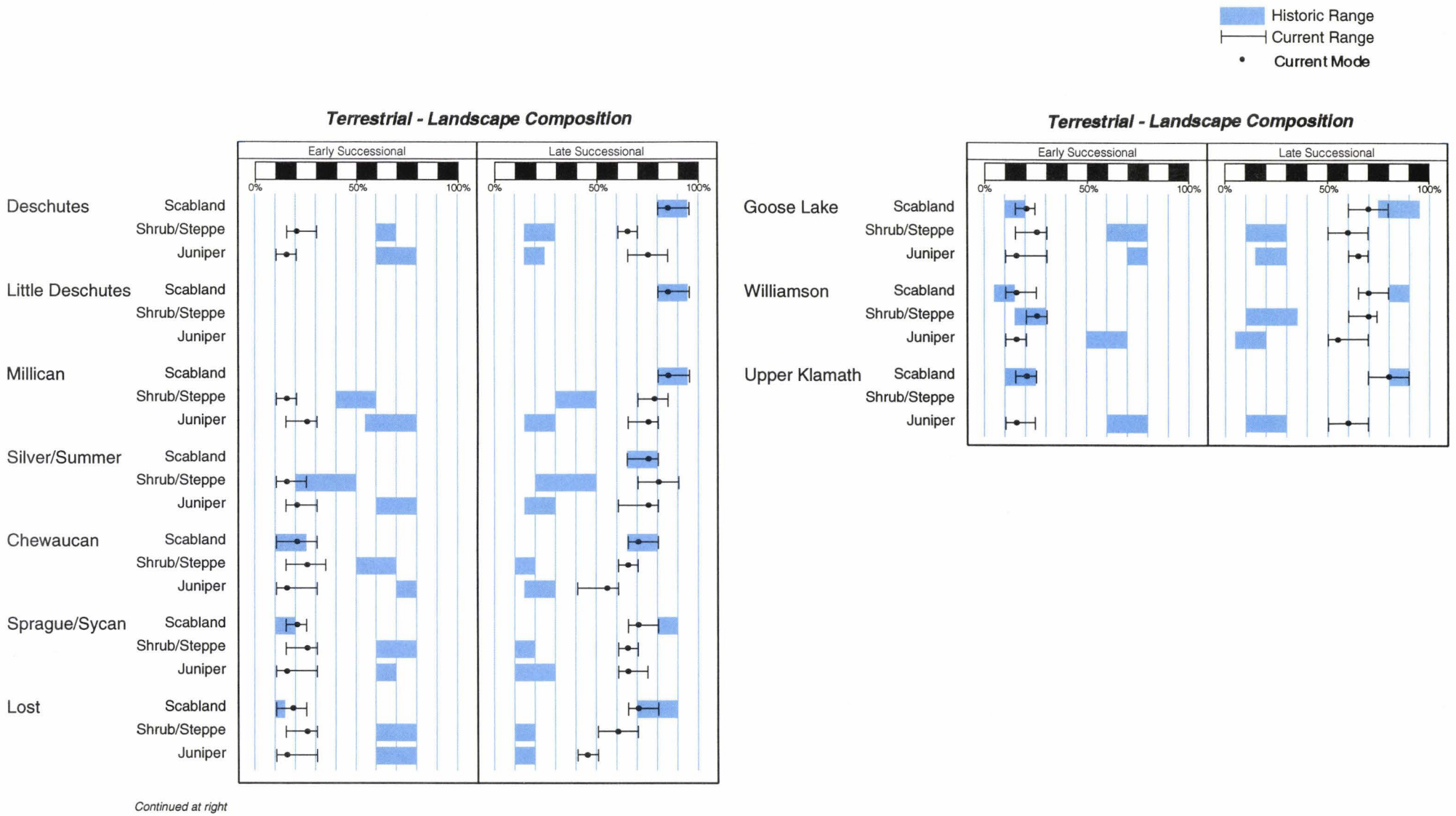

Historic Range
Current Range
Current Mode
Terrestrial - Landscape Composition
River Basins
Series
Early Successional – No Snags
Early Successional – With Snags
Late Successional – Single Layer
Late Successional – Multilayered
Low Vigor
0%
50%
100%
Deschutes
ALL
PONDEROSA
LODGEPOLE
WHITE FIR
MT. HEMLOCK
Little Deschutes
ALL
PONDEROSA
LODGEPOLE
WHITE FIR
MT. HEMLOCK
Millican
ALL
PONDEROSA
LODGEPOLE
WHITE FIR
Silver/Summer
ALL
PONDEROSA
LODGEPOLE
WHITE FIR
MT. HEMLOCK
Chewaucan
ALL
PONDEROSA
LODGEPOLE
WHITE FIR
Spraque/Sycan
ALL
PONDEROSA
LODGEPOLE
WHITE FIR

Figure 31 Subregional summary of ecological elements from river basins on the Deschutes, Fremont, and Winema National Forests. Historic range, current range, and current mode of measures described in the Methods section.




Historic Range
Current Range
Current Mode
Terrestrial - Landscape Composition
Early Successional
Late Successional
0%
50%
100%
Deschutes
Little Deschutes
Millican
Silver/Summer
Chewaucan
Sprague/Sycan
Lost
Scabland
Shrub/Steppe
Juniper
Continued at right
Terrestrial - Landscape Composition
Goose Lake
Williamson
Upper Klamath

Southwest Oregon: The Umpqua, Rogue, and Siskiyou National Forests

The Mediterranean climate of southwest Oregon interacts with several old geological provinces to maintain a unique combination of species and produce a disturbance regime unlike temperate northwest Oregon. Although there are remnants of old stands they rarely represent a single age class, which would indicate a major episode of intense, extensive burning. The oldest stands average less than 250 years old and have burned at least four times. Frequent underburning is the primary disturbance regime, but fires can be extensive and severe, thus it is almost impossible to reestablish pre-1850 fire boundaries.

Establishing a range of natural variability requires assumptions about the climate, the fire regime, and the activities of Native Americans; it remains a questionable reference point. In southwest Oregon the range of natural variability was defined as a reference point based on conditions before timber harvesting began in the early to mid-1900's.

River basins generally have less early successional vegetation compared with the reference range, with the exception of the Smith River basin which is within the reference range. Although harvesting has been ongoing in these river basins, the amount of disturbance resulting in early successional vegetation has been, with one exception, less than that caused by the frequent natural fire regime. This could reflect interference with fire disturbance cycles.

Roads and tractor logging on gentle slopes have increased the amount of impermeable soils compared with naturally impermeable conditions, such as rock outcrops.

Aquatic conditions may have been altered in the past 30 to 60 years. Pool frequency information was available for only the Applegate and Upper Rogue River basins, and current data show frequencies to be at the low end of the reference range. Current maximum stream temperatures are higher than the reference range on the Upper Rogue, Coquille, Elk-Sixes, Illinois, and Lower Rogue basins, and within the reference range for the others. Past disturbances, including management history, climatic change, and dams have influenced both stream temperature and pool frequency.

Riparian conditions vary between river basins, particularly for percent of stream with late successional vegetation. Current condition for late successional vegetation varies from substantially less than the reference range in the Smith River basin to much higher in the Applegate basin. Most of the basins were within or close to the reference range.

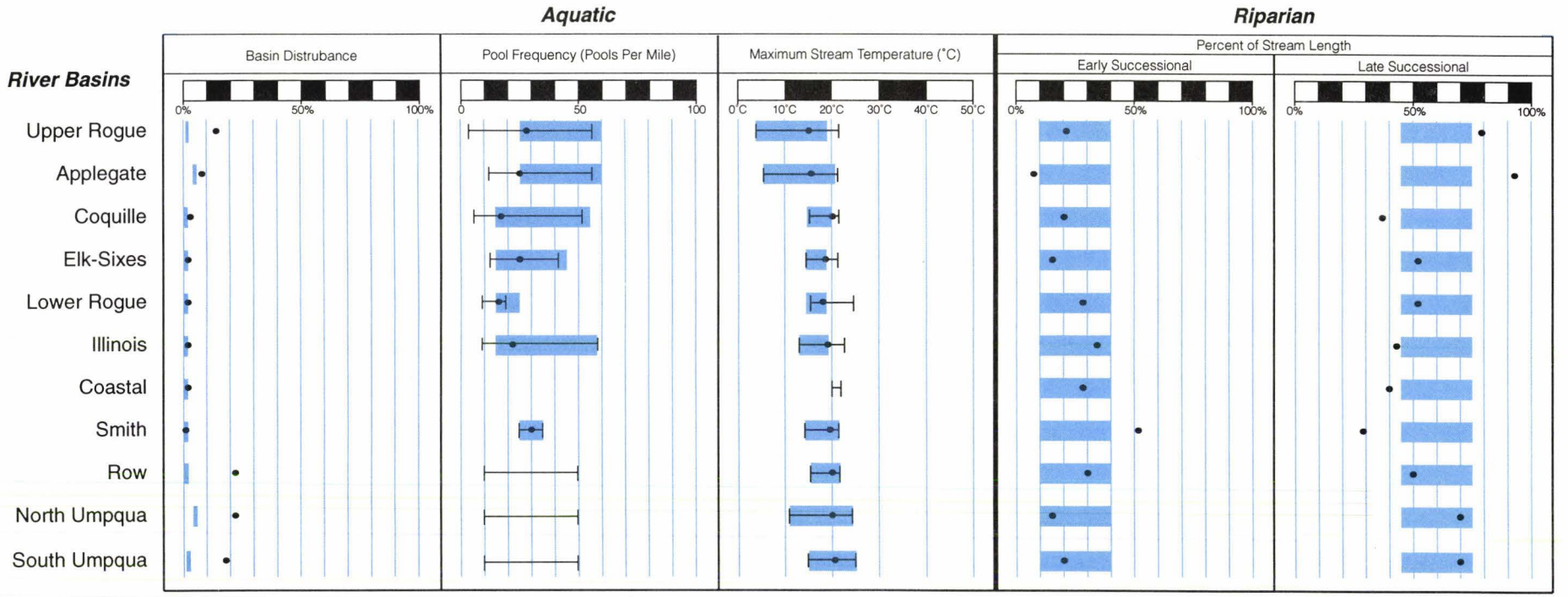
After fire disturbance, many snags are often present along with early successional vegetation. Current condition in all basins of southwest Oregon show a reduction in the amount of early successional vegetation with snags and an increase in early successional vegetation without snags.

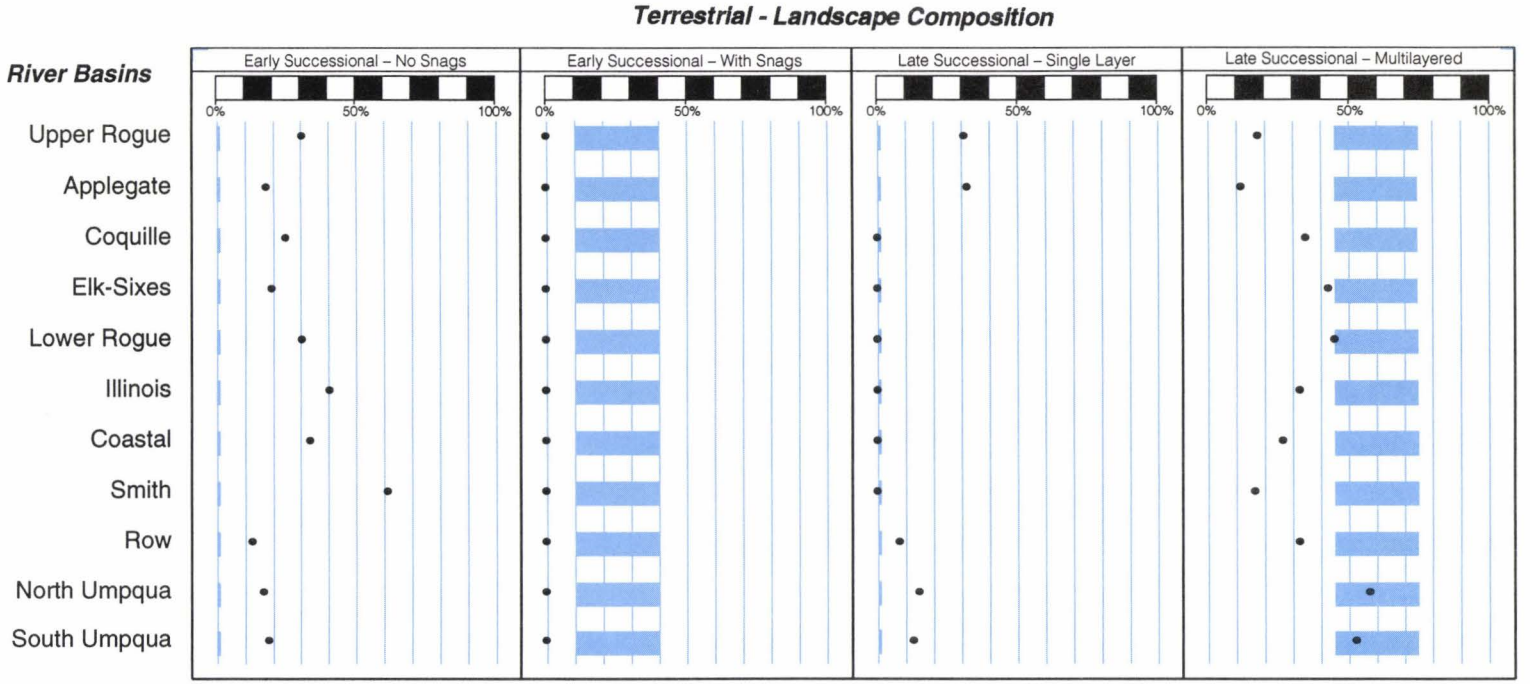
Late successional, multilayered stands are estimated to range from 40 to 75 percent of the area. Most of the basins are below this reference range. Late successional, single layered stands are generally equal to or above the reference range. This suggests a reduction in stand structure complexity. Single layered stands may occur in both natural and managed stands.

In summary, early successional acres increased in terrestrial systems and decreased in riparian systems. In aquatic systems pool frequency decreased and temperature increased. The direction of change is not surprising; it reflects management activities, fire prevention, successional changes, and responses to current climate. The trends toward simplification of the aquatic systems may not be continuing in Forest Service lands with present practices. In general, the status of ecosystems in Forest Service land in southwest Oregon is moderately healthy.

Data are illustrated in figure 32.

Figure 32 Subregional summary of ecological elements from river basins on the Siskiyou, Umpqua, and Rogue River National Forests. Historic range, current range and current mode of measures described in Methods section.




Terrestrial - Landscape Composition
River Basins
Early Successional – No Snags
Early Successional – With Snags
Late Successional – Single Layer
Late Successional – Multilayered
0%
50%
100%
Upper Rogue
Applegate
Coquille
Elk-Sixes
Lower Rogue
Illinois
Coastal
Smith
Row
North Umpqua
South Umpqua

West Central Oregon: The Siuslaw and Willamette National Forests

The fire disturbance regimes appear different for the ecosystems in the coastal Siuslaw National Forest and the Willamette National Forest located in the Cascade Mountains. The Coast Range is characterized by an infrequent (150 to 300 year mean fire return interval), fairly high intensity fire regime. A series of fires from the 1830's through the 1920's created early successional vegetation conditions in many areas, making it difficult to use current age class data for determining fire history and pattern. Fires were assumed to be largely stand-replacing and could affect 75 to 90 percent (10,000 to 300,000 acres) of the basin. Prolonged early successional conditions likely resulted from loss of seed source in the large stand-replacement fires. In contrast, the Cascades are generally drier and have higher frequency, lower intensity fires.

Aquatic and riparian habitats appear to have changed from the range of natural variability. Most streams in the managed landscapes exhibit significant signs of degraded habitat conditions. Most streams are below the range of natural variability in pools per mile and many have exceeded the maximum summer temperature. This is true for streams in both the Siuslaw and Willamette National Forests. Late successional conditions in most basins are within the range of natural variability. Practices such as salvage, sanitation, and selection harvest removed important elements of old growth, such as logs and snags; however, no forest-wide records were available.

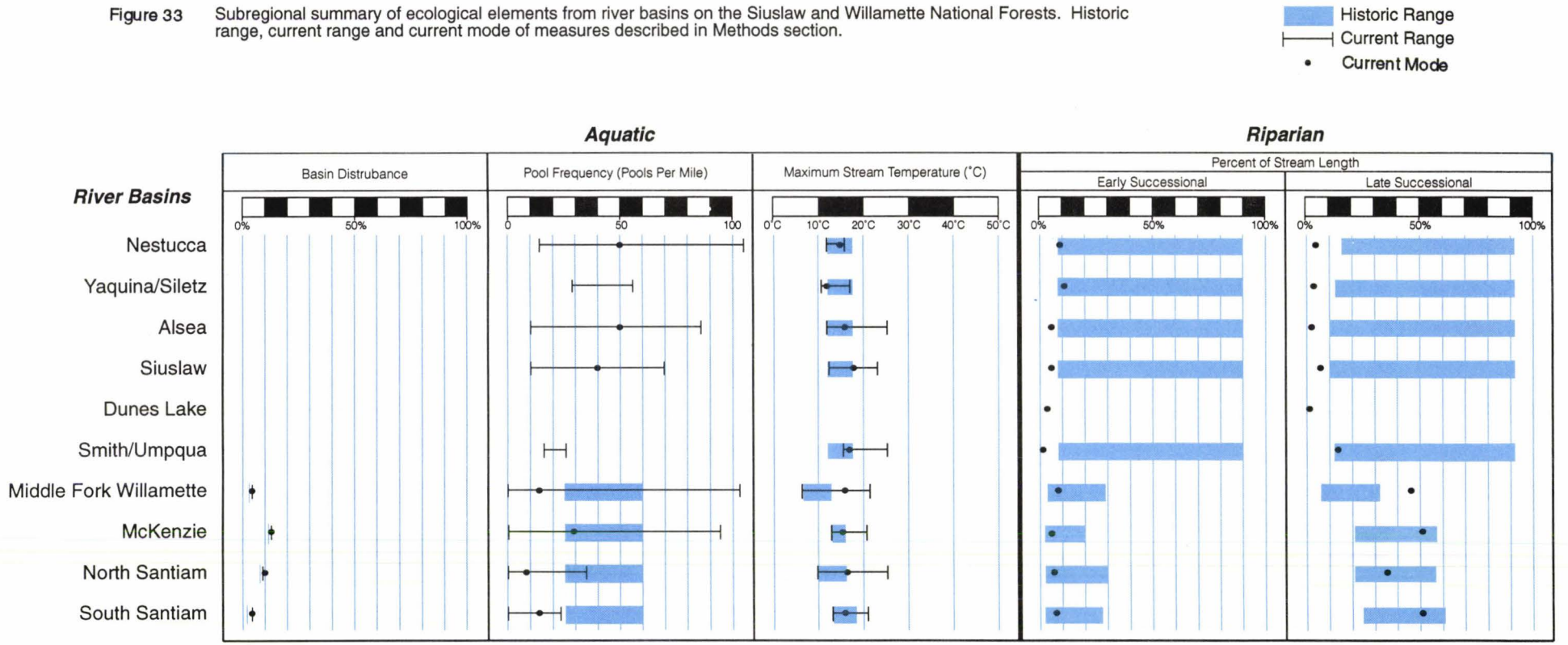
In the Siuslaw National Forest, the amount of early successional vegetation is mostly within the range of natural variability. In the Willamette National Forest, the amount of early successional is also within the range of natural variability. However, evidence shows the conditions in naturally occurring young forests is much different than plantations which contain substantially fewer snags and logs. If the amount of early successional and managed stands, ages 11 to 50 years, are considered together, in many areas the range of natural variability has been exceeded.

In the Siuslaw National Forest the amount of late successional, multilayered forest in all basins is below or near the lower limit of the range of natural variability. In the Willamette National Forest, the amount of late successional, multilayer forest is either below or near the lower limit of range of natural variability in most vegetation zones. In the mountain hemlock zone, in the basin of the Middle Fork of the Willamette River, the amount of late successional vegetation exceeds natural conditions. In the other basins it falls within the range of natural variability.

Landscape composition has changed significantly. Historical fire patterns produced large patches of early successional vegetation in the Siuslaw National Forest. For example, in 1850 the north coast between Tillamook and Astoria was dominated by late successional conditions, while the area between Newport and Reedsport was dominated by young, recently burned vegetation. There were large, relatively homogeneous stands across the landscape, with little edge and abundant areas of interior forest conditions. Today the Siuslaw National Forest is a fine textured, homogeneous mosaic of small patches less than 40 years old within a matrix of predominantly middle-aged stands. Dispersed cutting patterns have resulted in smaller stands of late successional vegetation with higher edge to area ratios and little to no interior habitat. In the Willamette National Forest over 50 percent of the acreage in regeneration units, up to 50 years old, are in patches of less than 75 acres. Dispersed cutting patterns resulted in smaller stands of late successional vegetation with higher edge to area ratios and much lower proportions of interior habitat than would be expected under a natural disturbance regime. Many of the large, unfragmented blocks of forest are in wilderness areas.

Data are illustrated in figure 33.

Figure 33 Subregional summary of ecological elements from river basins on the Siuslaw and Willamette National Forests. Historic range, current range and current mode of measures described in Methods section.



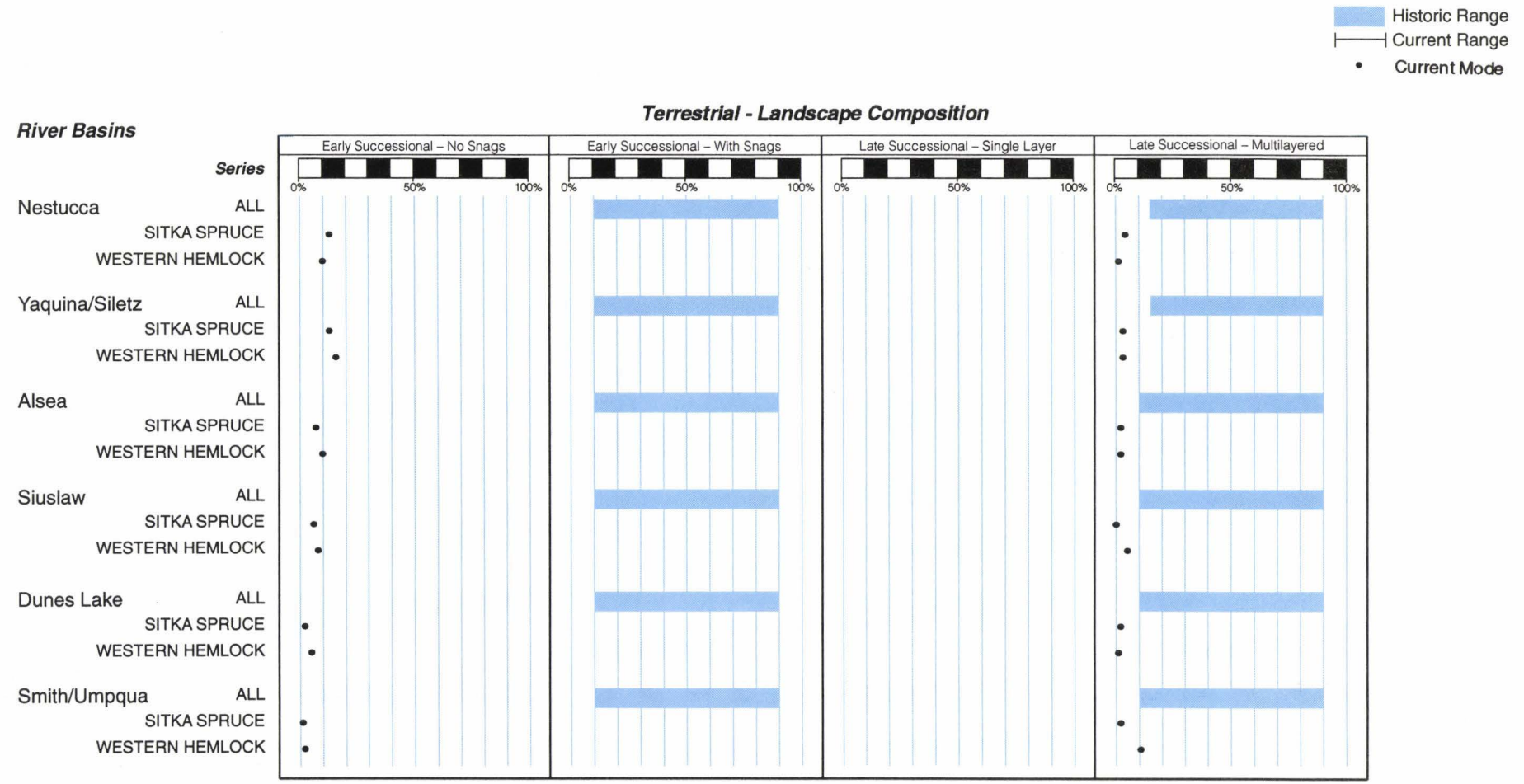
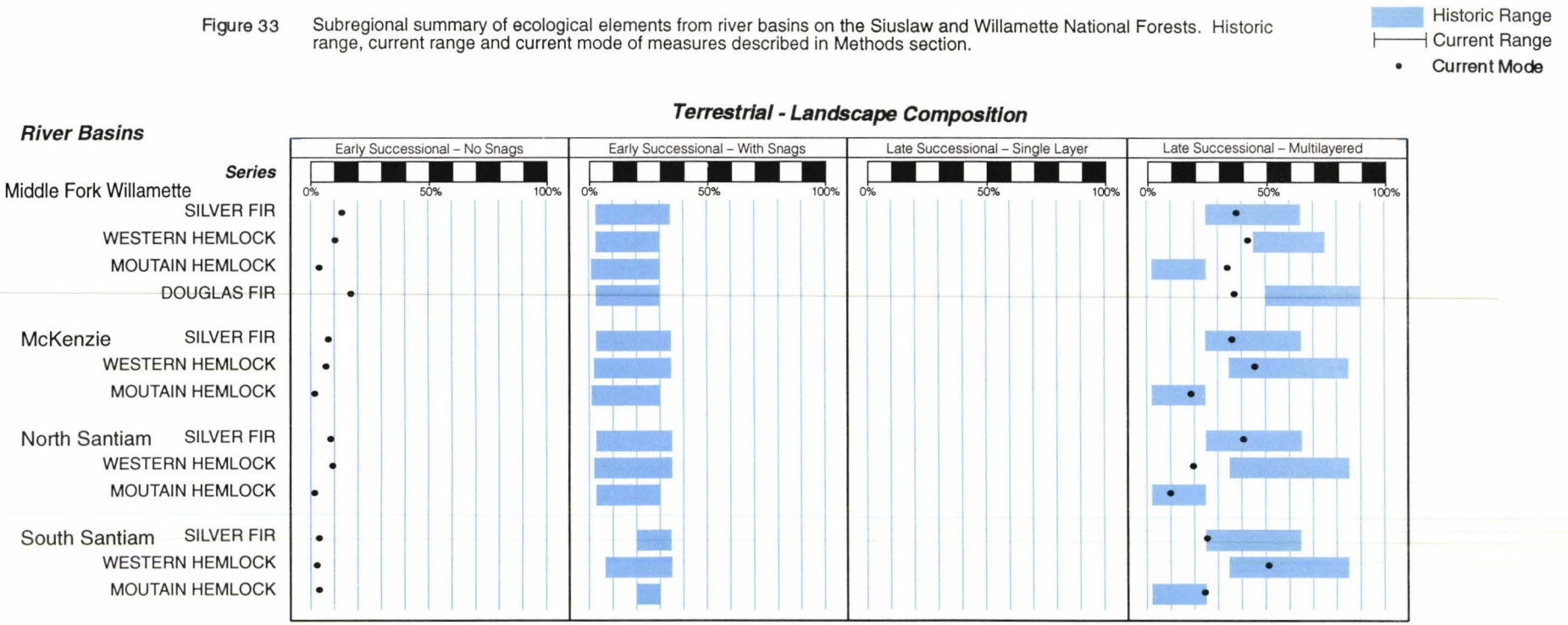

Historic Range
Current Range
Current Mode
Terrestrial - Landscape Composition
River Basins
Series
Early Successional – No Snags
Early Successional – With Snags
Late Successional – Single Layer
Late Successional – Multilayered
0%
50%
100%
Nestucca
ALL
SITKA SPRUCE
WESTERN HEMLOCK
Yaquina/Siletz
ALL
SITKA SPRUCE
WESTERN HEMLOCK
Alsea
ALL
SITKA SPRUCE
WESTERN HEMLOCK
Siuslaw
ALL
SITKA SPRUCE
WESTERN HEMLOCK
Dunes Lake
ALL
SITKA SPRUCE
WESTERN HEMLOCK
Smith/Umpqua
ALL
SITKA SPRUCE
WESTERN HEMLOCK

Figure 33 Subregional summary of ecological elements from river basins on the Siuslaw and Willamette National Forests. Historic range, current range and current mode of measures described in Methods section.



Columbia River: The Gifford Pinchot and Mt. Hood National Forests and the Columbia River Gorge National Scenic Area

Fire disturbance regimes for the Gifford Pinchot and Mt. Hood National Forests are intermediate along a gradient between those found in cool, wet and warm, and dry climatic conditions. A wide variety of fire sizes, intensities and frequencies characterizes the fire regime.

East of the Cascade crest prehistoric fires occurred from one to a few decades apart. They were typically low intensity fires that only partially replaced the overstory. The area near the crest of the High Cascades probably experienced the most severe fires, with large stand-replacement fires occurring a few to several centuries apart. This may be due to a combination of low relief between the major volcanic peaks and high incidence of lightning. On the west flank of the Cascades, a combination of dissected topography and high climatic variability resulted in a complex pattern of both stand-replacement and underburn fires. Stand-replacement fires appear to have occurred at intervals of two to eight centuries apart, with lower slope positions and northerly aspects burning less frequently and intensely. Between major stand-replacement fires, underburning appears to have been fairly common.

Another type of stand-replacement event occurred recently in this area, volcanic eruption. This had major impacts on conversion from late to early successional vegetation conditions and aquatic and riparian conditions in some river basins.

The percent of river basin disturbed, measured as a reduction of infiltration capacity, varied widely throughout the subregion. The range of natural variability of impermeable ground, including rock and flooded meadow, varied between 0.7 and 13.7 percent. Current conditions of impermeable ground varied between 1.5 and 38.7 percent. All basins have experienced an increase.

Aquatic measurements of pools per mile and maximum annual water temperature showed some change from the range of natural variability. Current condition of pools per mile overlapped the lower end of natural. Stream temperatures generally extended higher than range of natural variability; however, almost all modes fell within the natural range.

The amount of early successional vegetation in the stream influence zone fell within the lower half of the natural range for most of the basins. One exception was the Lewis River basin which has a high amount of early successional vegetation, probably the result of recent volcanic eruption. The other exception was the Clackamas River basin; the reasons could not be accounted for. Although the percent of early successional vegetation in the riparian influence zone is estimated to be similar today as it was in pre-settlement times, the spatial distribution was undoubtedly very different. Fire events would have maintained the early successional vegetation in large patches rather than dispersed throughout the riparian zone.

Major river basins had low percentages of both early successional and late successional vegetation currently as compared to range of natural variability. Exceptions are the basins around Mt. Saint Helens that have a high amount of early successional vegetation as a result of the 1980 volcanic eruption. This may be explained by management practices and changes in the role of fire. Under management, stands grow faster, hence the amount of time in early successional conditions is shortened. Harvesting is concentrated in older stands and thus tends to reduce the amount of this class.

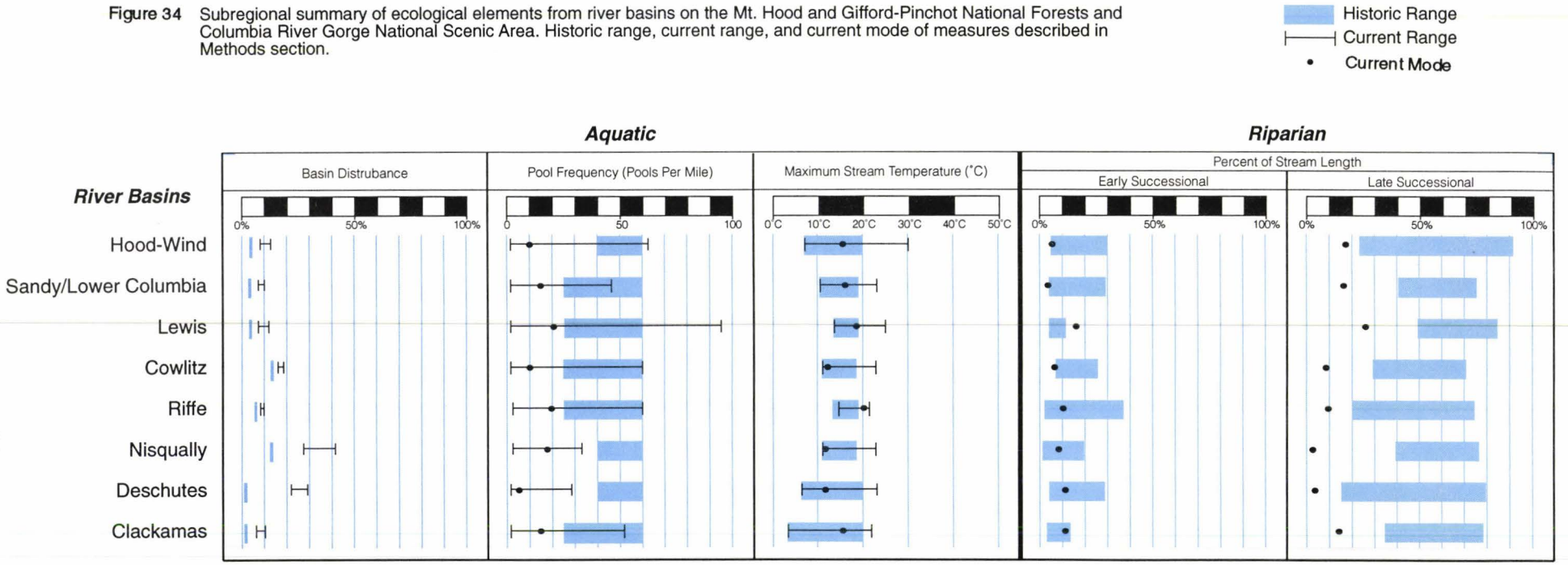
Large fire events as recently as 1902-1920 also contributed to reductions in the amount of late successional vegetation currently present, whereas current suppression of such fire events has reduced the amount of early successional vegetation created by fires. Historical fire events periodically created large openings which in turn may have been great distances from seed sources. Combined with occasional reburns, stands often may have remained in an early successional condition many decades longer than at present. It stands to reason that the amount of mid-successional vegetation may be greatly increased from what is natural.

By reducing the acres and time in the early successional and late successional stages, the structure and function of these stages may shift and affect the role that various successional stages play in the landscape. In addition, patch size and shape have contributed to patterns and ecosystem function, and appear to be quite different than natural conditions, with current sizes being smaller and dispersed.

The mountain hemlock zone has lower timber productivity and accessibility and thus has less fragmentation compared with the silver fir and western hemlock zones. In all zones, large patches of early successional vegetation are rare. Large patches of mid to late successional vegetation exist, but are concentrated in roadless areas.

Data are illustrated in Figure 34. Hood/Wind and Sandy river basins are divided by the Columbia River, and have lands managed by all three administrative units: Mt. Hood and Gifford Pinchot National Forests, and the Columbia River Gorge National Scenic Area. For Figures 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18 the Gifford Pinchot Forest is listed as the primary land manager for simplicity.

Figure 34 Subregional summary of ecological elements from river basins on the Mt. Hood and Gifford-Pinchot National Forests and Columbia River Gorge National Scenic Area. Historic range, current range, and current mode of measures described in Methods section.



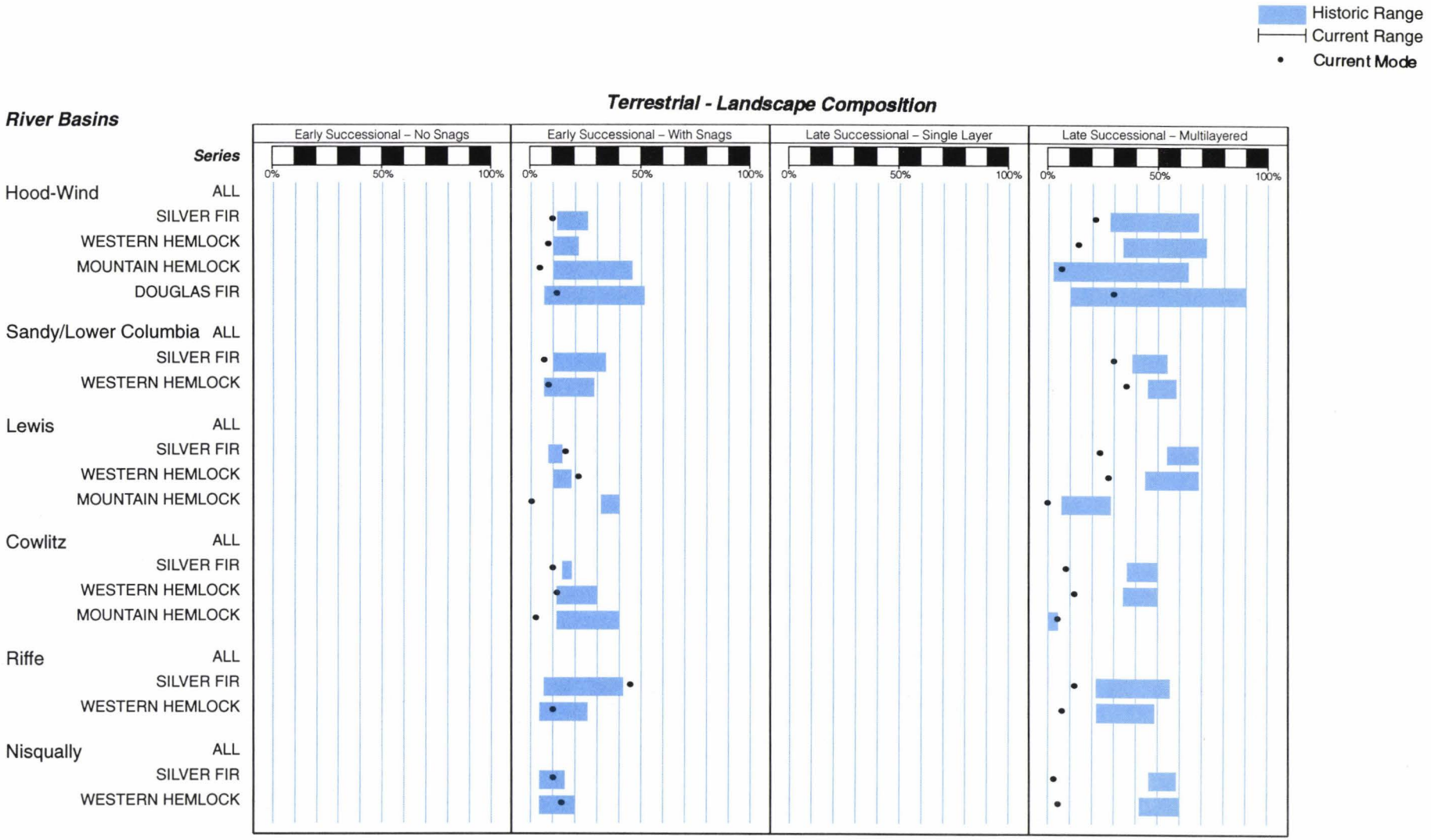
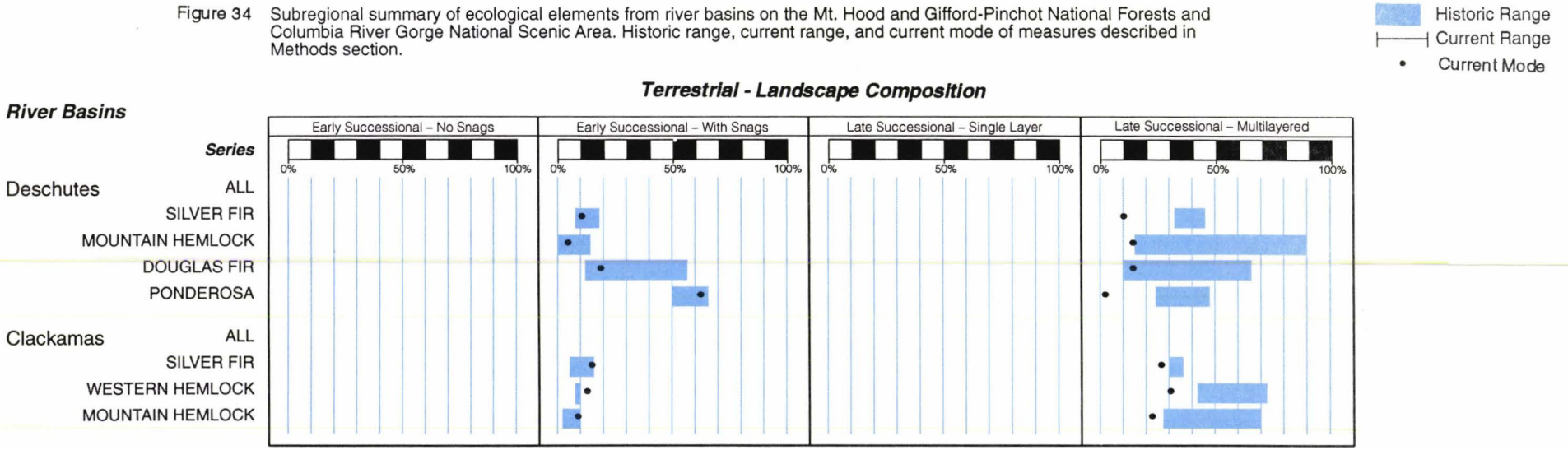

Historic Range
Current Range
Current Mode
Terrestrial - Landscape Composition
River Basins
Series
Early Successional – No Snags
Early Successional – With Snags
Late Successional – Single Layer
Late Successional – Multilayered
0%
50%
100%
Hood-Wind
ALL
SILVER FIR
WESTERN HEMLOCK
MOUNTAIN HEMLOCK
DOUGLAS FIR
Sandy/Lower Columbia
ALL
SILVER FIR
WESTERN HEMLOCK
Lewis
ALL
SILVER FIR
WESTERN HEMLOCK
MOUNTAIN HEMLOCK
Cowlitz
ALL
SILVER FIR
WESTERN HEMLOCK
MOUNTAIN HEMLOCK
Riffe
ALL
SILVER FIR
WESTERN HEMLOCK
Nisqually
ALL
SILVER FIR
WESTERN HEMLOCK

Figure 34 Subregional summary of ecological elements from river basins on the Mt. Hood and Gifford-Pinchot National Forests and Columbia River Gorge National Scenic Area. Historic range, current range, and current mode of measures described in Methods section.



Eastern Washington: Wenatchee, Okanogan, and Colville National Forests

This summary highlights results of the Eastside Forest Ecosystem Health Assessment (Volume III) that are pertinent to the Regional Ecological Assessment Project. The Eastside Forest Health Assessment reported on current and historical aquatic and terrestrial ecosystem parameters for the Yakima, Wenatchee, Methow, and Pend Oreille River basins of eastern Washington.

The river basins along the Cascade Mountains (Entiat, Chelan, Similkameen, and Okanogan) are very similar in these attributes to sampled adjacent river basins (Methow, Wenatchee, and Upper and Lower Yakima). Therefore, conclusions drawn from the Methow can confidently be applied to Chelan, Similkameen, and Okanogan river basins. Results from the Wenatchee river basin should be applicable to the Entiat river basin as long as the data from the sedimentary, ultrabasic, and maritime climatic areas of the Wenatchee river basin are not extrapolated to the Entiat river basin.

Results from the Pend Oreille can be applied to the Colville and Upper Columbia river basins with care. The Pend Oreille river basin is really very different in climate and vegetation from watersheds to the west.

That leaves the Kettle and Sanpoil River basins. The Methow basin is the only one that is relatively close in terms of climate, geology, and vegetation. However, as seen by the similarity analysis at the plant association level, the degree of similarity is low. The Sanpoil and Kettle basins are distinct from river basins to the east and west. The central Kettle and Sanpoil basins are more like the Methow in the riparian series than like the Pend Oreille. The drier riparian associations in the Pend Oreille and the low elevation types (below 5,500 foot elevation) in the Methow somewhat represent the Kettle and Sanpoil.

Given the scales and resolutions specified by the first phase of the REAP analysis, results from the Methow can be carefull extrapolated to the east (Kettle and Sanpoil). Keep in mind that conclusions will be tenuous.

Aquatic Systems

Changes in Frequency of Large Pools

McIntosh and others (Assessment Volume III) provided information on changes in frequency of large pools (20m2 area and 1.0 m deep) in intensively and custodial managed portions of selected river basins in the Columbia river basin from 1935 to 1992. The Wenatchee, Yakima and Methow river basins were sampled in Eastern Washington. Frequency of large pools increased in both intensively and custodial managed portions of these river basins:

River Basin	% Changed Intensively Managed	% Changed Custodial Managed
Yakima	111%	144%
Methow	94%	240%
Wenatchee	57%	156%

Large woody debris, numbers and size, were less (50%) in intensively managed than custodial managed portions of these same river basins (McIntosh and others, 1993).

Terrestrial Systems

Change in Wetlands

There was no significant change in area of forested and nonforested wetlands within sampled drainage basins (Lehmkuhl and others, Assessment Volume III, 1993). The trend was toward an increase in wetland area; however, there were both positive and negative changes by watersheds within basins.

Percent of River Basin Disturbed

Change in Uplands

Forested ecosystems are altered by both disturbance effects in excess of historical levels and by the prevention of disturbance effects. Lehmkuhl and others (Assessment Volume III) reported total forest cover decreased significantly in the Wenatchee River basin but was not significantly different from historical levels in the Methow, Pend Oreille and Yakima River basins.

Decline in Early-Successional Species

Dramatic shifts occurred in composition of the forest overstory from early successional species to more shade tolerant species. There was a general decline in ponderosa pine, larch and western white pine cover with an increase in Douglas-fir cover. In the Pend Oreille basin the area of western hemlock, subalpine fir and Englemann spruce understory increased over 200 percent.

The area occupied by grass/forb communities decreased in Methow, Pend Oreille, and Yakima basins but increased in the Wenatchee.

Lemkhuel and others were unable to demonstrate statistically significant changes in amounts of bare ground within sampled basins, although it increased by 79 percent in the Yakima basin.

Change in Forest Structure

In the Methow basin there was a loss of mature park-like and old forest structural classes and an increase in young forest area. In the Yakima basin there was an 80 percent reduction in old forest area and a 50 percent increases in seedling/sapling/pole stands. Changes in the Wenatchee basin were opposite with an 18 percent decrease in young stands and a 26 percent increase in old forest area.

Forest areas having no dead trees declined significantly in the Wenatchee and Yakima basins and there was a corresponding increase in acreage containing 10 percent or less dead trees.

Diversity of landscape vegetation patterns increased and patch size declined in each of the four drainage basins sampled. Landscapes have become more fragmented in intensively managed forests.

References Cited (Eastern Washington: Wenatchee, Okanogan, and Colville National Forests)

Lehmkuhl, J.; Hessburg P; and others. 1993. Historical and current vegetation pattern and associated changes in insect an disease hazard and fire and smoke conditions in eastern Oregon and Washington. IN Volume III. Eastside Forest Ecosystem Health Assessment.

McIntosh, B; Sedell, J.; and others. 1993. Management history of eastside ecosystems:changes in fish habitat over 50 years, 1935 to 1992. IN Volume III. Eastside Forest Ecosystem Health Assessment.

Smith, B.; Kovalchick, B. and Lillybridge, T. 1993. "Comparison of Eastern Washington Hydrologic Units".

Appendix A - Summary of Review Comments

A two level review of assessment results took place from late April through May 1993. Subregional results were reviewed by specialists at the local level, and a regional review group considered all assessment results. The subregional process mainly focused upon validating the data. The remainder of Appendix A summarizes regional review comments. Many review comments were incorporated into this final document.

The following list summarizes the organizations and agencies asked to participate in the regional review process. Not all individuals contacted were able to participate.

Academic

University of Washington

Oregon State University

State Government

State of Washington

Department of Fisheries

Department of Natural Resources

Department of Wildlife

State of Oregon

Department of Fish and Wildlife

Department of Forestry

Federal Government

U. S. Forest Service -
Regional Offices for R1, R6 and R5
Pacific Northwest Research Station

Bureau of Land Management

Bureau of Indian Affairs

U. S. Fish and Wildlife Service

U. S. Department of Commerce, National Marine Fisheries Service

Tribal Government

Quinault Indian Nation

Yakima Indian Nation

Northwest Indian Fisheries Commission

Review comments are grouped into six common themes. They are:

- commendations,
- consistency,
- data and assumptions,
- next step, and
- partnerships.

A summary of the general tone and tenor of the comments is presented with several quotations (in italic print) offered as examples.

Commendations

The draft assessment was characterized by reviewers as a job well done. *"This effort is a valuable 1st step that is essential to land management planning and implementation at all levels --- from site to watershed to landscape to forest to region."* Accolades were offered for using the Sustaining Ecological Systems (SES) approach. Other commendations were offered for:

- the use of diagnostic indicators;
- utilizing a landscape approach;
- providing summary statements of assumptions;
- graphical displays; and
- the coordinated effort on a region-wide basis.

Consistency

Consistency within data elements and between reporting units represented the greatest area of concern. Statements such as this one provide insight to the issue: *"There is a lack of consistency in the data presented and even in format. It would really be tough to aggregate these to address a region wide issue like old growth or salmon,"* and *"The tone and completeness of the presentation of materials* (and, to a lesser extent, the format) *varies dramatically from forest to forest, and sometimes, from HUC to HUC."*

Several reviewers suggested that a collaborative, multi-agency strategy must be developed for future monitoring. Multi-agency data collection protocols are necessary to facilitate sharing of information.

Data and Assumptions

"Vegetation data bases have been poorly kept on some forests and quality varies among districts within forests. Lots of assumptions were made, and these were not documented well except in the Columbia River document." This quote captures the tone found in most of the respondent's letters when reflecting on the quality and quantity of the data presented. Numerous data gaps exist without adequate explanation. A quote reflecting this concern states, *"There are many notes throughout the documents on missing data and out-of-date inventories that underscore the need for more complete, updated inventory and monitoring data of an ecological nature."*

Adequate documentation of the assumptions was further referenced as a problem. The Columbia River Area report was described as an exception to this complaint. *"I am even more skeptical about the estimation of the range of natural conditions. I found that the procedures were poorly documented in all but the Columbia River document, and I spent a lot of time trying to figure out how the ranges were estimated."* Other statements referencing the historic range were critical of the data presented, such as, *"Appearance of use of a blanket upper and lower number of pools per mile makes the results seem suspect to the reader who is aware of the natural variability that occurs from stream to stream."* Reviewers emphasized the need to have credible and consistent assumptions that were well documented.

Next Step

Reviewers did not want to overshadow the fact that the assessment was an excellent first approximation. However, without additional plans to improve data management, data collection, interpretation of the consequences and management implications of ecosystems being outside the historic range, this first effort will be labeled as a job not yet complete. *"The current REAP is a good, but very narrow assessment. A full blown effort is needed that will enable managers and the public to judge how FS lands are being managed and what changes need to be made to assure the FS is truly headed toward Ecosystem Management."* One reviewer suggested that departures from the range of natural variability by river basin only display part of the picture. *"... but also the areas that are at the highest risk from alteration,"* need to be considered. *"It would appear rational in an assessment of this type to point out those basins*

where there is a higher than otherwise percentage of highly erosive soils; or highly unstable streambanks."

The next step as viewed by many advisors should be more comprehensive. *"There is a need for information that facilitates the kind and extent of ecological type conversion as well as succession stages. For example, many high elevation Pacific Silver Fir or mixed stands have been converted to Douglas fir; in the Blue Mountains, Ponderosa pine has been converted to Douglas fir and mixed conifers; in rangelands, bunchgrasses have been replaced by cheatgrass, etc. This kind of information is needed to anticipate potential problems associated with landscape level conversions."*

Partnerships

Another common review comment addressed the need for interagency cooperation in an ecological approach. Non-Forest Service reviewers reported that they were eager to participate and seem ready to move towards a holistic approach to management of ecosystems in the northwest.

The Oregon Department of Forestry voiced their support of an all agency assessment, as seen in the following quotation from a letter sent to the White House Office on Environmental Policy from Jim Brown, Oregon State Forester. *"At that meeting, I discussed an opportunity for Oregon Department of Forestry to join with USDA Forest Service and USDI-BLM in order to assess the condition of all forest lands in Oregon - non-federal as well as the federal lands ... This information will provide important information to policy makers as they try to determine how to implement ecosystem management across ownerships ... We believe that information generated by the ecosystem analysis process is vital for every manager and regulator to have and to use before proceeding with decisions to implement ecosystem management on a multi-ownership basis. The various landowners, public and private, must have a comprehensive data base that covers all the affected ownerships in a watershed or drainage basin. The analyses need to be made in concert with all affected landowners and must be based on the best available, multi-ownership data."*

Appendix B - Genetics Recommendations

The role of genetics in ecosystem management is that of a fine filter test of the assumptions used in coarse filter ecosystem assessments. There are two major attributes of genetic information which must be considered:

- Genetic information in nature is organized by species. Each species has unique patterns of genetic variation. This means that baseline levels of genetic variation will be different among species even without considering effects of management and human use of these species.
- The scale used to assess genetic information will vary. The species distribution gives the manager a clue as to which scale to use. For example, coniferous species distribution can cover several western states and extend into Canada and/or Mexico. But even for these extensive distributions, there are isolated patches of the species which may be important to sample and monitor at the watershed level.

Landscape Assessment

We may have an opportunity to work with the Olympic National Forest data in terms of gene flow and other landscape genetic questions, as their data is linked to species through the TRI system and they have good stand age data vis a vis their work with fire history in the Olympic peninsula. We will explore this data to see if we can make meaningful genetic interpretations at a landscape level.

Baseline Levels of Genetic Variation

Winnie Kessler stated in her 4/9/93 paper, that "development of a conceptual framework, indicators, and methods to evaluate the condition and health of the systems we manage are urgently needed." We need to develop a process for monitoring baseline levels of biological diversity of our forest ecosystems. Secondly, we need to know how our management practices are changing these baseline levels of diversity. One component of biological diversity is genetic diversity.

In terms of monitoring baseline levels of genetic variation and monitoring of how this baseline level is affected by management, geneticists can offer a conceptual framework and eventually some data. Using isozymes we can measure several attributes of genetic variation for one to several species in the natural and the managed conditions at time zero (1993). We can subsequently remeasure these same genetic attributes at time N for both the natural and managed conditions. Let me give you an example.

We are currently cooperating in a study at the OSU school forest using isozymes (isozymes are gene products related to enzymes) to measure attributes of genetic variation for Douglas-fir in unmanaged stands and under various silviculture treatments. This genetics work is being done by Dr. Tom Adams at Oregon State University in partnership with the Pacific Northwest Region Genetics Resource Program. The genetics part of the study could be expanded to include other species. Other scientists could also monitor the effects of management on invertebrates and non-vascular plants (such as lichens) in the study area. In addition to increasing the scope of the monitoring work being done within this one location, there is the opportunity to set up similar studies in other locations.

We propose initiating a similar study at the Wind River Ranger District of the Gifford Pinchot National Forest. The T. T. Munger Natural Area and the Wind River Experimental Forest represent an opportunity to monitor various aspects of biodiversity in the managed and unmanaged condition. We have already planned to collect some dormant Douglas-fir buds from trees in this vicinity this spring for isozyme analysis at the National Gel Electrophoresis Laboratory in Placerville, California. We welcome the collaboration of other scientists for development of the best study design to maximize information and statistical integrity to monitor elements of biodiversity in the managed and unmanaged condition.

I would propose that these types of monitoring plots be established at various locations in the Pacific Northwest Region using Research Natural Areas to represent the primary core of "natural" environments to monitor.

Threatened and Endangered Species

We are planning to do an isozyme study at the National Gel Electrophoresis Laboratory this year on Frasera umpquaensis. The study objective is to determine if patches of this rare species represent one large or several small populations of the species. The answer to this question will affect the design of management practices used to restore the species.

Gene Conservation

I am working in partnership with public and private land holders in Washington and Oregon to develop a regional approach to gene conservation. We define gene conservation as maintenance of genetic variation in target species which assures their ability to evolve and to adapt to the conditions they will encounter in space and time. Our comprehensive strategy will include various gene conservation tactics such as: building genetic diversity into tree breeding populations, regional provenance tests to study the response of trees to different environments and climates, developing a dynamic approach to conservation of forest stands using both plantations and naturally regenerated stands, ecosystem reserves such as Research Natural Areas, and genetic libraries of seed or clonal materials.

Genetic Variation and Isolated Populations as a GIS Layer

We have an opportunity during the next year of creating a GIS layer which displays patterns of genetic variation of coniferous tree species reported in the literature which occur in the Pacific Northwest Region. We may also be able to locate this type of data from other than coniferous tree studies. It may be possible using existing GIS data layers to discover locations of isolated populations of species. All this information could be incorporated onto a GIS layer which would then make it retrievable for use by land managers. This will take some time as we would need to design an approach to the problem. We would also need to have GIS resources available to us in order to complete the task.

Summary

Genetic data can best be used in the next round or in fine tuning of ecological assessments. We have the opportunity to set up monitoring of our forest ecosystems in such a way to include genetic information which will complement monitoring of various levels of biological information.

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